

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 662 003 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
29.01.2003 Bulletin 2003/05

(51) Int Cl.7: **C12N 15/11**, A61K 31/70,
C07H 21/04

(21) Application number: **93921230.4**

(86) International application number:
PCT/US93/08101

(22) Date of filing: **27.08.1993**

(87) International publication number:
WO 94/005333 (17.03.1994 Gazette 1994/07)

(54) OLIGONUCLEOTIDE MODULATION OF CELL ADHESION

BEEINFLUSSUNG DER ZELLADHÄSIE DURCH OLIGONUKLEOTIDE

MODULATION OLIGONUCLEOTIDIQUE DE L'ADHESION CELLULAIRE

(84) Designated Contracting States:
**AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL
PT SE**

(30) Priority: **02.09.1992 US 939855**
21.01.1993 US 7997
17.05.1993 US 63167

(43) Date of publication of application:
12.07.1995 Bulletin 1995/28

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Description**FIELD OF THE INVENTION**

[0001] This invention relates to diagnostics, research reagents and therapies for disease states which respond to modulation of the synthesis or metabolism of cell adhesion molecules. In particular, this invention relates to antisense oligonucleotide interactions with certain messenger ribonucleic acids (mRNAs) or DNAs involved in the synthesis of proteins that regulate adhesion of white blood cells to other white blood cells and to other cell types. Antisense oligonucleotides designed to hybridize to the mRNA encoding intercellular adhesion molecule-1 (ICAM-1), endothelial leukocyte adhesion molecule-1 (ELAM-1, also known as E-selectin), and vascular cell adhesion molecule-1 (VCAM-1) are provided. These oligonucleotides have been found to lead to the modulation of the activity of the RNA or DNA, and thus to the modulation of the synthesis and metabolism of specific cell adhesion molecules. Palliation and therapeutic effect result.

BACKGROUND OF THE INVENTION

[0002] Inflammation is a localized protective response elicited by tissues in response to injury, infection, or tissue destruction resulting in the destruction of the infectious or injurious agent and isolation of the injured tissue. A typical inflammatory response proceeds as follows: recognition of an antigen as foreign or recognition of tissue damage, synthesis and release of soluble inflammatory mediators, recruitment of inflammatory cells to the site of infection or tissue damage, destruction and removal of the invading organism or damaged tissue, and deactivation of the system once the invading organism or damage has been resolved. In many human diseases with an inflammatory component, the normal, homeostatic mechanisms which attenuate the inflammatory responses are defective, resulting in damage and destruction of normal tissue.

[0003] Cell-cell interactions are involved in the activation of the immune response at each of the stages described above. One of the earliest detectable events in a normal inflammatory response is adhesion of leukocytes to the vascular endothelium, followed by migration of leukocytes out of the vasculature to the site of infection or injury. The adhesion of these leukocytes, or white blood cells, to vascular endothelium is an obligate step in the migration out of the vasculature. Harlan, J.M., *Blood* **1985**, 65, 513-525. In general, the first inflammatory cells to appear at the site of inflammation are neutrophils followed by monocytes, and lymphocytes. Cell-cell interactions are also critical for propagation of both B-lymphocytes and T-lymphocytes resulting in enhanced humoral and cellular immune responses, respectively.

[0004] The adhesion of white blood cells to vascular endothelium and other cell types is mediated by interactions between specific proteins, termed "adhesion molecules," located on the plasma membrane of both white blood cells and vascular endothelium. The interaction between adhesion molecules is similar to classical receptor ligand interactions with the exception that the ligand is fixed to the surface of a cell instead of being soluble. The identification of patients with a genetic defect in leukocyte adhesion has enabled investigators to identify a family of proteins responsible for adherence of white blood cells. Leukocyte adhesion deficiency (LAD) is a rare autosomal trait characterized by recurrent bacterial infections and impaired pus formation and wound healing. The defect was shown to occur in the common B-subunit of three heterodimeric glycoproteins, Mac-1, LFA-1, and p150,95, normally expressed on the outer cell membrane of white blood cells. Anderson and Springer, *Ann. Rev. Med.* **1987**, 38, 175-194. Patients suffering from LAD exhibit a defect in a wide spectrum of adherence-dependent functions of granulocytes, monocytes, and lymphocytes. Three ligands for LFA-1 have been identified, intercellular adhesion molecules 1, 2 and 3 (ICAM-1, ICAM-2 and ICAM-3). Both Mac-1 and p150,95 bind complement fragment C3bi and perhaps other unidentified ligands. Mac-1 also binds ICAM-1.

[0005] Other adhesion molecules have been identified which are involved in the adherence of white blood cells to vascular endothelium and subsequent migration out of the vasculature. These include endothelial leukocyte adhesion molecule-1 (ELAM-1), vascular cell adhesion molecule-1 (VCAM-1) and granule membrane protein-140 (GMP-140) and their respective receptors. The adherence of white blood cells to vascular endothelium appears to be mediated in part if not *in toto* by the five cell adhesion molecules ICAM-1, ICAM-2, ELAM-1, VCAM-1 and GMP-140. Dustin and Springer, *J. Cell Biol.* **1987**, 107, 321-331. Expression on the cell surface of ICAM-1, ELAM-1, VCAM-1 and GMP-140 adhesion molecules is induced by inflammatory stimuli. In contrast, expression of ICAM-2 appears to be constitutive and not sensitive to induction by cytokines. In general, GMP-140 is induced by autotoxins such as histamine, leukotriene B₄, platelet activating factor, and thrombin. Maximal expression on endothelial cells is observed 30 minutes to 1 hour after stimulation, and returns to baseline within 2 to 3 hours. The expression of ELAM-1 and VCAM-1 on endothelial cells is induced by cytokines such as interleukin-1 β and tumor necrosis factor, but not gamma-interferon. Maximal expression of ELAM-1 on the surface of endothelial cells occurs 4 to 6 hours after stimulation, and returns to baseline by 16 hours. ELAM-1 expression is dependent on new mRNA and protein synthesis. Elevated VCAM-1 expression is

detectable 2 hours following treatment with tumor necrosis factor, is maximal 8 hours following stimulation, and remains elevated for at least 48 hours following stimulation. Rice and Bevilacqua, *Science* **1989**, 246, 1303-1306. ICAM-1 expression on endothelial cells is induced by cytokines interleukin-1 tumor necrosis factor and gamma-interferon. Maximal expression of ICAM-1 follows that of ELAM-1 occurring 8 to 10 hours after stimulation and remains elevated for at least 48 hours.

[0006] GMP-140 and ELAM-1 are primarily involved in the adhesion of neutrophils to vascular endothelial cells. VCAM-1 primarily binds T and B lymphocytes. In addition, VCAM-1 may play a role in the metastasis of melanoma, and possibly other cancers. ICAM-1 plays a role in adhesion of neutrophils to vascular endothelium, as well as adhesion of monocytes and lymphocytes to vascular endothelium, tissue fibroblasts and epidermal keratinocytes. ICAM-1 also plays a role in T-cell recognition of antigen presenting cell, lysis of target cells by natural killer cells, lymphocyte activation and proliferation, and maturation of T cells in the thymus. In addition, recent data have demonstrated that ICAM-1 is the cellular receptor for the major serotype of rhinovirus, which account for greater than 50% of common colds. Staunton et al., *Cell* **1989**, 56, 849-853; Greve et al., *Cell* **1989**, 56, 839-847.

[0007] Expression of ICAM-1 has been associated with a variety of inflammatory skin disorders such as allergic contact dermatitis, fixed drug eruption, lichen planus, and psoriasis; Ho et al., *J. Am. Acad. Dermatol.* **1990**, 22, 64-68; Griffiths and Nickoloff, *Am. J. Pathology* **1989**, 135, 1045-1053; Lisby et al., *Br. J. Dermatol.* **1989**, 120, 479-484; Shiohara et al., *Arch. Dermatol.* **1989**, 125, 1371-1376. In addition, ICAM-1 expression has been detected in the synovium of patients with rheumatoid arthritis; Hale et al., *Arth. Rheum.* **1989**, 32, 22-30, pancreatic B-cells in diabetes; Campbell et al., *Proc. Natl. Acad. Sci. U.S.A.* **1989**, 86, 4282-4286; thyroid follicular cells in patients with Graves' disease; Weetman et al., *J. Endocrinol.* **1989**, 122, 185-191; and with renal and liver allograft rejection; Faull and Russ, *Transplantation* **1989**, 48, 226-230; Adams et al., *Lancet* **1989**, 1122-1125.

[0008] It has been hoped that inhibitors of ICAM-1, VCAM-1 and ELAM-1 expression would provide a novel therapeutic class of anti-inflammatory agents with activity towards a variety of inflammatory diseases or diseases with an inflammatory component such as asthma, rheumatoid arthritis, allograft rejections, inflammatory bowel disease, various dermatological conditions, and psoriasis. In addition, inhibitors of ICAM-1, VCAM-1, and SLAM-1 may also be effective in the treatment of colds due to rhinovirus infection, AIDS, Kaposi's sarcoma and some cancers and their metastasis. To date, there are no known therapeutic agents which effectively prevent the expression of the cellular adhesion molecules ELAM-1, VCAM-1 and ICAM-1. The use of neutralizing monoclonal antibodies against ICAM-1 in animal models provide evidence that such inhibitors if identified would have therapeutic benefit for asthma; Wegner et al., *Science* **1990**, 247, 456-459, renal allografts; Cosimi et al., *J. Immunol.* **1990**, 144, 4604-4612, and cardiac allografts; Isobe et al., *Science* **1992**, 255, 1125-1127. The use of a soluble form of ICAM-1 molecule was also effective in preventing rhinovirus infection of cells in culture. Marlin et al., *Nature* **1990**, 344, 70-72.

[0009] Current agents which affect intercellular adhesion molecules include synthetic peptides, monoclonal antibodies, and soluble forms of the adhesion molecules. To date, synthetic peptides which block the interactions with VCAM-1 or ELAM-1 have not been identified. Monoclonal antibodies may prove to be useful for the treatment of acute inflammatory response due to expression of ICAM-1, VCAM-1 and ELAM-1. However, with chronic treatment, the host animal develops antibodies against the monoclonal antibodies thereby limiting their usefulness. In addition, monoclonal antibodies are large proteins which may have difficulty in gaining access to the inflammatory site. Soluble forms of the cell adhesion molecules suffer from many of the same limitations as monoclonal antibodies in addition to the expense of their production and their low binding affinity. Thus, there is a long felt need for molecules which effectively inhibit intercellular adhesion molecules. Antisense oligonucleotides avoid many of the pitfalls of current agents used to block the effects of ICAM-1, VCAM-1 and ELAM-1.

[0010] PCT/US90/02357 (Hession et al.) discloses DNA sequences encoding Endothelial Adhesion Molecules (ELAMs), including ELAM-1 and VCAM-1 and VCAM-Ib. A number of uses for these DNA sequences are provided, including (1) production of monoclonal antibody preparations that are reactive for these molecules which may be used as therapeutic agents to inhibit leukocyte binding to endothelial cells; (2) production of ELAM peptides to bind to the ELAM ligand on leukocytes which, in turn, may bind to ELAM on endothelial cells, inhibiting leukocyte binding to endothelial cells; (3) use of molecules binding to ELAMs (such as anti-ELAM antibodies, or markers such as the ligand or fragments of it) to detect inflammation; (4) use of ELAM and ELAM ligand DNA sequences to produce nucleic acid molecules that intervene in ELAM or ELAM ligand expression at the translational level using antisense nucleic acid and ribozymes to block translation of a specific mRNA either by masking mRNA with antisense nucleic acid or cleaving it with a ribozyme. It is disclosed that coding regions are the targets of choice. For VCAM-1, AUG is believed to be most likely; a 15-mer hybridizing to the AUG site is specifically disclosed in Example 17.

OBJECTS OF THE INVENTION

[0011] It is a principle object of the invention to provide therapies for diseases with an immunological component, allografts, cancers and metastasis, inflammatory bowel disease, psoriasis and other skin diseases, colds, and AIDS

through perturbation in the synthesis and expression of inflammatory cell adhesion molecules.

[0012] It is a further object of the invention to provide antisense oligonucleotides which are capable of inhibiting the function of nucleic acids encoding VCAM-1.

[0013] Yet another object is to provide means for diagnosis of dysfunctions of intercellular adhesion.

[0014] These and other objects of this invention will become apparent from a review of the instant specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIGURE 1 is the mRNA sequence of human intercellular adhesion molecule-1 (ICAM-1).

[0016] FIGURE 2 is the mRNA sequence of human endothelial leukocyte adhesion molecule-1 (ELAM-1).

[0017] FIGURE 3 is the mRNA sequence of human vascular cell adhesion molecule-1 (VCAM-1).

[0018] FIGURE 4 is a graphical representation of the induction of ICAM-1 expression on the cell surface of various human cell lines by interleukin-1 and tumor necrosis factor.

[0019] FIGURE 5 is a graphical representation of the effects of selected antisense oligonucleotides on ICAM-1 expression on human umbilical vein endothelial cells.

[0020] FIGURE 6A and 6B are a graphical representation of the effects of an antisense oligonucleotide on the expression of ICAM-1 in human umbilical vein endothelial cells stimulated with tumor necrosis factor and interleukin-1.

[0021] FIGURE 7 is a graphical representation of the effect of antisense oligonucleotides on ICAM-1 mediated adhesion of DMSO differentiated HL-60 cells to control and tumor necrosis factor treated human umbilical vein endothelial cells.

[0022] FIGURE 8 is a graphical representation of the effects of selected antisense oligonucleotides on ICAM-1 expression in A549 human lung carcinoma cells.

[0023] FIGURE 9 is a graphical representation of the effects of selected antisense oligonucleotides on ICAM-1 expression in primary human keratinocytes.

[0024] FIGURE 10 is a graphical representation of the effects of selected antisense oligonucleotides on ELAM-1 expression on tumor necrosis factor-treated human umbilical vein endothelial cells.

SUMMARY OF THE INVENTION

[0025] In accordance with the present invention, oligonucleotides, as defined in claim 1 hereinafter, are provided which specifically hybridize with nucleic acids encoding vascular cell adhesion molecule-1 (VCAM-1). The oligonucleotides are designed to bind either directly to mRNA or to a selected DNA portion forming a triple stranded structure, thereby modulating the amount of mRNA made from the gene.

[0026] The former relationship is commonly denoted as "antisense." The oligonucleotides are able to inhibit the function of RNA or DNA, either its translation into protein, its translocation into the cytoplasm, or any other activity necessary to its overall biological function. The failure of the RNA or DNA to perform all or part of its function results in failure of a portion of the genome controlling cell adhesion molecules to be properly expressed, thus modulating said metabolism.

[0027] It is preferred to target specific genes for antisense attack. It has been discovered that the genes coding for VCAM-1 are particularly useful for this approach. Inhibition of VCAM-1 expression is expected to be useful for the treatment of inflammatory diseases, diseases with an inflammatory component, allograft rejection, psoriasis and other skin diseases, inflammatory bowel disease, cancers and their metastasis, and viral infections.

[0028] Methods of modulating cell adhesion comprising contacting the animal with an oligonucleotide, as defined in claim 1 hereinafter, hybridizable with nucleic acids encoding VCAM-1 are provided. Methods for diagnosis are also a part of this invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] Antisense oligonucleotides hold great promise as therapeutic agents for the treatment of many human diseases. Oligonucleotides specifically bind to the complementary sequence of either pre-mRNA or mature mRNA, as defined by Watson-Crick base pairing, inhibiting the flow of genetic information from DNA to protein. The properties of antisense oligonucleotides which make them specific for their target sequence also make them extraordinarily versatile. Because antisense oligonucleotides are long chains of four monomeric units they may be readily synthesized for any target RNA sequence. Numerous recent studies have documented the utility of antisense oligonucleotides as biochemical tools for studying target proteins. Rothenberg et al., *J. Natl. Cancer Inst.* **1989**, 81, 1539-1544; Zon, G. *Pharmaceutical Res.* **1988**, 5, 539-549). Because of recent advances in synthesis of nuclease resistant oligonucleotides, which exhibit enhanced cell uptake, it is now possible to consider the use of antisense oligonucleotides as a novel form of therapeutics.

[0030] Antisense oligonucleotides offer an ideal solution to the problems encountered in prior art approaches. They can be designed to selectively inhibit a given isoenzyme, they inhibit the production of the enzyme, and they avoid non-specific mechanisms such as free radical scavenging or binding to multiple receptors. A complete understanding of enzyme mechanisms or receptor-ligand interactions is not needed to design specific inhibitors.

DESCRIPTION OF TARGETS

[0031] The acute infiltration of neutrophils into the site of inflammation appears to be due to increased expression of GMP-140, ELAM-1 and ICAM-1 on the surface of endothelial cells. The appearance of lymphocytes and monocytes during the later stages of an inflammatory reaction appear to be mediated by VCAM-1 and ICAM-1. ELAM-1 and GMP-140 are transiently expressed on vascular endothelial cells, while VCAM-1 and ICAM-1 are chronically expressed.

[0032] Human ICAM-1 is encoded by a 3.3-kb mRNA resulting in the synthesis of a 55,219 dalton protein (Figure 1). ICAM-1 is heavily glycosylated through N-linked glycosylation sites. The mature protein has an apparent molecular mass of 90 kDa as determined by SDS-polyacrylamide gel electrophoresis. Staunton et al., *Cell* **1988**, 52, 925-933. ICAM-1 is a member of the immunoglobulin supergene family, containing 5 immunoglobulin-like domains at the amino terminus, followed by a transmembrane domain and a cytoplasmic domain. The primary binding site for LFA-1 and rhinovirus are found in the first immunoglobulin-like domain. However, the binding sites appear to be distinct. Staunton et al., *Cell* **1990**, 61, 243-354. Recent electron micrographic studies demonstrate that ICAM-1 is a bent rod 18.7 nm in length and 2 to 3 nm in diameter. Staunton et al., *Cell* **1990**, 61, 243-254.

[0033] ICAM-1 exhibits a broad tissue and cell distribution, and may be found on white blood cells, endothelial cells, fibroblast, keratinocytes and other epithelial cells. The expression of ICAM-1 can be regulated on vascular endothelial cells, fibroblasts, keratinocytes, astrocytes and several cell lines by treatment with bacterial lipopolysaccharide and cytokines such as interleukin-1, tumor necrosis factor, gamma-interferon, and lymphotoxin. See, e.g., Frohman et al., *J. Neuroimmunol.* **1989**, 23, 117-124. The molecular mechanism for increased expression of ICAM-1 following cytokine treatment has not been determined.

[0034] ELAM-1 is a 115-kDa membrane glycoprotein (Figure 2) which is a member of the selectin family of membrane glycoproteins. Bevilacqua et al., *Science* **1989**, 243, 1160-1165. The amino terminal region of ELAM-1 contains sequences with homologies to members of lectin-like proteins, followed by a domain similar to epidermal growth factor, followed by six tandem 60-amino acid repeats similar to those found in complement receptors 1 and 2. These features are also shared by GMP-140 and MEL-14 antigen, a lymphocyte homing antigen. ELAM-1 is encoded for by a 3.9-kb mRNA. The 3'-untranslated region of ELAM-1 mRNA contains several sequence motifs ATTTA which are responsible for the rapid turnover of cellular mRNA consistent with the transient nature of ELAM-1 expression.

[0035] ELAM-1 exhibits a limited cellular distribution in that it has only been identified on vascular endothelial cells. Like ICAM-1, ELAM-1 is inducible by a number of cytokines including tumor necrosis factor, interleukin-1 and lymphotoxin and bacterial lipopolysaccharide. In contrast to ICAM-1, ELAM-1 is not induced by gamma-interferon. Bevilacqua et al., *Proc. Natl. Acad. Sci. USA* **1987**, 84, 9238-9242; Wellicome et al., *J. Immunol.* **1990**, 144, 2558-2565. The kinetics of ELAM-1 mRNA induction and disappearance in human umbilical vein endothelial cells precedes the appearance and disappearance of ELAM-1 on the cell surface. As with ICAM-1 the molecular mechanism for ELAM-1 induction is not known.

[0036] VCAM-1 is a 110-kDa membrane glycoprotein encoded by a 3.2-kb mRNA (Figure 3). VCAM-1 appears to be encoded by a single-copy gene which can undergo alternative splicing to yield products with either six or seven immunoglobulin domains. Osborn et al., *Cell* **1989**, 59, 1203-1211. The receptor for VCAM-1 is proposed to be CD29 (VLA-4) as demonstrated by the ability of monoclonal antibodies to CD29 to block adherence of Ramos cells to VCAM-1. VCAM-1 is expressed primarily on vascular endothelial cells. Like ICAM-1 and ELAM-1, expression of VCAM-1 on vascular endothelium is regulated by treatment with cytokines. Rice and Bevilacqua, *Science* **1989**, 246, 1303-1306; Rice et al., *J. Exp. Med.* **1990**, 171, 1369-1374. Increased expression appears to be due to induction of the mRNA.

[0037] For therapeutics, an animal suspected of having a disease which can be treated by decreasing the expression of ICAM-1, VCAM-1 and ELAM-1 is treated by administering oligonucleotides in accordance with this invention. Oligonucleotides may be formulated in a pharmaceutical composition, which may include carriers, thickeners, diluents, buffers, preservatives, surface active agents, liposomes or lipid formulations and the like in addition to the oligonucleotide. Pharmaceutical compositions may also include one or more active ingredients such as antimicrobial agents, anti-inflammatory agents, anesthetics, and the like in addition to oligonucleotide.

[0038] The pharmaceutical composition may be administered in a number of ways depending on whether local or systemic treatment is desired, and on the area to be treated. Administration may be topically (including ophthalmically, vaginally, rectally, intranasally), orally, by inhalation, or parenterally, for example by intravenous drip, subcutaneous, intraperitoneal or intramuscular injection.

[0039] Formulations for topical administration may include ointments, lotions, creams, gels, drops, suppositories, sprays, liquids and powders. Conventional pharmaceutical carriers, aqueous, powder or oily bases, thickeners and

the like may be necessary or desirable. Coated condoms or gloves may also be useful.

[0040] Compositions for oral administration include powders or granules, suspensions or solutions in water or non-aqueous media, capsules, sachets, or tablets. Thickeners, flavorings, diluents, emulsifiers, dispersing aids or binders may be desirable.

[0041] Formulations for parenteral administration may include sterile aqueous solutions which may also contain buffers, liposomes, diluents and other suitable additives.

[0042] Dosing is dependent on severity and responsiveness of the condition to be treated, but will normally be one or more doses per day, with course of treatment lasting from several days to several months or until a cure is effected or a diminution of disease state is achieved. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and repetition rates.

[0043] The present invention employs oligonucleotides for use in antisense inhibition of the function of RNA and DNA corresponding to VCAM-1. In the context of this invention, the term "oligonucleotide" refers to an oligomer or polymer of ribonucleic acid or deoxyribonucleic acid. This term includes oligomers consisting of naturally occurring bases, sugars and intersugar (backbone) linkages as well as oligomers having non-naturally occurring portions which function similarly. Such modified or substituted oligonucleotides are often preferred over native forms because of properties such as, for example, enhanced cellular uptake and increased stability in the presence of nucleases.

[0044] Specific examples of some preferred oligonucleotides envisioned for this invention may contain phosphorothioates, phosphotriesters, methyl phosphonates, short chain alkyl or cycloalkyl intersugar linkages or short chain heteroatomic or heterocyclic intersugar linkages. Most preferred are those with $\text{CH}_2\text{-NH-O-CH}_2$, $\text{CH}_2\text{-N(CH}_3\text{)-O-CH}_2$, $\text{CH}_2\text{-O-N(CH}_3\text{)-CH}_2$, $\text{CH}_2\text{-N(CH}_3\text{)-N(CH}_3\text{)-CH}_2$ and $\text{O-N(CH}_3\text{)-CH}_2\text{-CH}_2$ backbones (where phosphodiester is O-P-O-CH_2). Also preferred are oligonucleotides having morpholino backbone structures. Summerton, J.E. and Weller, D.D., U.S. Patent 5,034,506. In other preferred embodiments, such as the protein-nucleic acid (PNA) backbone, the phosphodiester backbone of the oligonucleotide may be replaced with a polyamide backbone, the bases being bound directly or indirectly to the aza nitrogen atoms of the polyamide backbone. P.E. Nielsen, M. Egholm, R.H. Berg, O. Buchardt, *Science* **1991**, 254, 1497. Other preferred oligonucleotides may contain alkyl and halogen-substituted sugar moieties comprising one of the following at the 2' position: OH, SH, SCH_3 , F, OCN, $\text{O(CH}_2\text{)}_n\text{NH}_2$ or $\text{O(CH}_2\text{)}_n\text{CH}_3$ where n is from 1 to about 10; C_1 to C_{10} lower alkyl, substituted lower alkyl, alkaryl or aralkyl; Cl; Br; CN; CF_3 ; OCF_3 ; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; SOCH_3 ; SO_2CH_3 ; ONO_2 ; NO_2 ; N_3 ; NH_2 ; heterocycloalkyl; heterocycloalkaryl; aminoalkylamino; polyalkylamino; substituted silyl; an RNA cleaving group; a conjugate; a reporter group; an intercalator; a group for improving the pharmacokinetic properties of an oligonucleotide; or a group for improving the pharmacodynamic properties of an oligonucleotide and other substituents having similar properties. Oligonucleotides may also have sugar mimetics such as cyclobutyls in place of the pentofuranosyl group.

[0045] The oligonucleotides in accordance with this invention preferably comprise from about 3 to about 50 nucleic acid base units. It is more preferred that such oligonucleotides comprise from about 8 to 25 nucleic acid base units, and still more preferred to have from about 12 to 22 nucleic acid base units. As will be appreciated, a nucleic acid base unit is a base-sugar combination suitably bound to an adjacent nucleic acid base unit through phosphodiester or other bonds.

[0046] The oligonucleotides used in accordance with this invention may be conveniently and routinely made through the well-known technique of solid phase synthesis. Equipment for such synthesis is sold by several vendors including Applied Biosystems. Any other means for such synthesis may also be employed, however the actual synthesis of the oligonucleotides are well within the talents of the routineer. It is also well known to use similar techniques to prepare other oligonucleotides such as the phosphorothioates and alkylated derivatives.

[0047] In accordance with this invention, persons of ordinary skill in the art will understand that messenger RNA identified by the open reading frames (ORFs) of the DNA from which they are transcribed includes not only the information from the ORFs of the DNA, but also associated ribonucleotides which form regions known to such persons as the 5'-untranslated region, the 3'- untranslated region, and intervening sequence ribonucleotides. Thus, oligonucleotides may be formulated in accordance with this invention which are targeted wholly or in part to these associated ribonucleotides as well as to the informational ribonucleotides. In preferred embodiments, the oligonucleotide is specifically hybridizable with a transcription initiation site, a translation initiation site, an intervening sequence and sequences in the 3'-untranslated region.

[0048] In accordance with this invention, the oligonucleotide is specifically hybridizable with portions of nucleic acids encoding a protein involved in the adhesion of white blood cells either to other white blood cells or other cell types. Said protein is vascular cell adhesion molecule-1. Oligonucleotides comprising the corresponding sequence, or part thereof, are useful in the invention.

[0049] Figure 3 is a human vascular cell adhesion molecule-1 mRNA sequence. A preferred sequence segment which may be useful in whole or in part is:

5'	3'	SEQ ID NO:
CCAGGCATTTTAAGTTGCTGT		40
	CCTGAAGCCAGTGAGGCCCG	41
	GATGAGAAAATAGTGAACCA	42
	CTGAGCAAGATATCTAGAT	43
	CTACACTTTTGATTTCTGT	44
	TTGAACATATCAAGCATTAGCT	45
	TTTACATATGTACAAATTATGT	46
	AATTATCACTTTACTATACAAA	47
	AGGGCTGACCAAGACGGTTGT.	48

While the illustrated sequences are believed to be accurate, the present invention is directed to the correct sequences should errors be found. Oligonucleotides useful in the invention comprise one of these sequences, or part thereof. Thus, it is preferred to employ any of these oligonucleotides as set forth above or any of the similar oligonucleotides which persons of ordinary skill in the art can prepare from knowledge of the preferred antisense targets for the modulation of the synthesis of inflammatory cell adhesion molecules.

[0050] Several preferred embodiments of this invention are exemplified in accordance with the following nonlimiting examples. The target mRNA species for modulation relate to vascular cell adhesion molecule-1. Persons of ordinary skill in the art will appreciate that the present invention is not so limited, however, and that it is generally applicable. The inhibition or modulation of production of the VCAM-1 is expected to have significant therapeutic benefits in the treatment of disease. In order to assess the effectiveness of the compositions, an assay or series of assays is required.

EXAMPLES

Example 1

[0051] Expression of ICAM-1, VCAM-1 and ELAM-1 on the surface of cells can be quantitated using specific monoclonal antibodies in an ELISA. Cells are grown to confluence in 96 well microtiter plates. The cells are stimulated with either interleukin-1 or tumor necrosis factor for 4 to 8 hours to quantitate ELAM-1 and 8 to 24 hours to quantitate ICAM-1 and VCAM-1. Following the appropriate incubation time with the cytokine, the cells are gently washed three times with a buffered isotonic solution containing calcium and magnesium such as Dulbecco's phosphate buffered saline (D-PBS). The cells are then directly fixed on the microtiter plate with 1 to 2% paraformaldehyde diluted in D-PBS for 20 minutes at 25°C. The cells are washed again with D-PBS three times. Nonspecific binding sites on the microtiter plate are blocked with 2% bovine serum albumin in D-PBS for 1 hour at 37°C. Cells are incubated with the appropriate monoclonal antibody diluted in blocking solution for 1 hour at 37°C. Unbound antibody is removed by washing the cells three times with D-PBS. Antibody bound to the cells is detected by incubation with a 1:1000 dilution of biotinylated goat anti-mouse IgG (Bethesda Research Laboratories, Gaithersburg, MD) in blocking solution for 1 hour at 37°C. Cells are washed three times with D-PBS and then incubated with a 1:1000 dilution of streptavidin conjugated to β -galactosidase (Bethesda Research Laboratories) for 1 hour at 37°C. The cells are washed three times with D-PBS for 5 minutes each. The amount of β -galactosidase bound to the specific monoclonal antibody is determined by developing the plate in a solution of 3.3 mM chlorophenolred- β -D-galactopyranoside, 50 mM sodium phosphate, 1.5 mM $MgCl_2$; pH=7.2 for 2 to 15 minutes at 37°C. The concentration of the product is determined by measuring the absorbance at 575 nm in an ELISA microtiter plate reader.

[0052] An example of the induction of ICAM-1 observed following stimulation with either interleukin-1 β or tumor necrosis factor α in several human cell lines is shown in Figure 4. Cells were stimulated with increasing concentrations of interleukin-1 or tumor necrosis factor for 15 hours and processed as described above. ICAM-1 expression was determined by incubation with a 1:1000 dilution of the monoclonal antibody 84H10 (Amac Inc., Westbrook, ME). The cell lines used were passage 4 human umbilical vein endothelial cells (HUVEC), a human epidermal carcinoma cell line (A431), a human melanoma cell line (SK-MEL-2) and a human lung carcinoma cell line (A549). ICAM-1 was induced on all the cell lines, however, tumor necrosis factor was more effective than interleukin-1 in induction of ICAM-1 expression on the cell surface (Figure 4).

[0053] Screening antisense oligonucleotides for inhibition of ICAM-1, VCAM-1 or ELAM-1 expression is performed as described above with the exception of pretreatment of cells with the oligonucleotides prior to challenge with the cytokines. An example of antisense oligonucleotide inhibition of ICAM-1 expression is shown in Figure 5. Human umbilical vein endothelial cells (HUVEC) were treated with increasing concentration of oligonucleotide diluted in Opti MEM (GIBCO, Grand Island, NY) containing 8 μ M N-[1-(2,3-dioleoyloxy) propyl]-N,N,N-trimethylammonium chloride (DOTMA) for 4 hours at 37°C to enhance uptake of the oligonucleotides. The medium was removed and replaced with endothelial growth medium (EGM-UV; Clonetics, San Diego, CA) containing the indicated concentration of oligonucleotide for an additional 4 hours. Interleukin-1 β was added to the cells at a concentration of 5 units/ml and incubated for 14 hours at 37°C. The cells were quantitated for ICAM-1 expression using a 1:1000 dilution of the monoclonal antibody 84H10 as described above. The oligonucleotides used were:

COMPOUND 1 - (ISIS 1558) a phosphodiester oligonucleotide designed to hybridize with position 64-80 of the mRNA covering the AUG initiation of translation codon having the sequence

5' -TGGGAGCCATAGCGAGGC-3' (SEQ ID NO: 1).

COMPOUND 2 - (ISIS 1570) a phosphorothioate containing oligonucleotide corresponding to the same sequence as COMPOUND 1.

COMPOUND 3 - a phosphorothioate oligonucleotide complementary to COMPOUND 1 and COMPOUND 2 exhibiting the sequence

5' -GCCTCGCTATGGCTCCCA-3' (SEQ ID NO: 81).

COMPOUND 4 - (ISIS 1572) a phosphorothioate containing oligonucleotide designed to hybridize to positions 2190-2210 of the mRNA in the 3' untranslated region containing the sequence

5' -GACACTCAATAAATAGCTGGT-3' (SEQ ID NO: 3).

COMPOUND 5 - (ISIS 1821) a phosphorothioate containing oligonucleotide designed to hybridize to human 5-lipoxygenase mRNA used as a control containing the sequence

5' -CATGGCGCGGGCCGCGGG-3' (SEQ ID NO: 82).

[0054] The phosphodiester oligonucleotide targeting the AUG initiation of translation region of the human ICAM-1 mRNA (COMPOUND 1) did not inhibit expression of ICAM-1, however, the corresponding phosphorothioate containing oligonucleotide (COMPOUND 2) inhibited ICAM-1 expression by 70% at a concentration of 0.1 μ M and 90% at 1 μ M concentration (Figure 4). The increased potency of the phosphorothioate oligonucleotide over the phosphodiester is probably due to increased stability. The sense strand to COMPOUND 2, COMPOUND 3, modestly inhibited ICAM-1 expression at 10 μ M. If COMPOUND 2 was prehybridized to COMPOUND 3 prior to addition to the cells, the effects of COMPOUND 2 on ICAM-1 expression were attenuated suggesting that the activity of COMPOUND 2 was due to antisense oligonucleotide effect, requiring hybridization to the mRNA. The antisense oligonucleotide directed against 3' untranslated sequences (COMPOUND 4) inhibited ICAM-1 expression 62% at a concentration of 1 μ M (Figure 5). The control oligonucleotide, targeting human 5-lipoxygenase (COMPOUND 5) reduced ICAM-1 expression by 20%. These data demonstrate that oligonucleotides are capable of inhibiting ICAM-1 expression on human umbilical vein endothelial cells and suggest that the inhibition of ICAM-1 expression is due to an antisense activity.

[0055] The antisense oligonucleotide COMPOUND 2 at a concentration of 1 μ M inhibits expression of ICAM-1 on human umbilical vein endothelial cells stimulated with increasing concentrations of tumor necrosis factor and interleukin-1 (Figure 6). These data demonstrate that the effects of COMPOUND 2 are not specific for interleukin-1 stimulation of cells.

[0056] Analogous assays can also be used to demonstrate inhibition of ELAM-1 and VCAM-1 expression by antisense oligonucleotides.

Example 2

[0057] A second cellular assay which can be used to demonstrate the effects of antisense oligonucleotides on ICAM-1, VCAM-1 or ELAM-1 expression is a cell adherence assay. Target cells are grown as a monolayer in a multiwell plate, treated with oligonucleotide followed by cytokine. The adhering cells are then added to the monolayer cells and incubated for 30 to 60 minutes at 37°C and washed to remove nonadhering cells. Cells adhering to the monolayer may be determined either by directly counting the adhering cells or prelabeling the cells with a radioisotope such as ⁵¹Cr and quantitating the radioactivity associated with the monolayer as described. Dustin and Springer, *J. Cell Biol.* **1988**, 107, 321-331. Antisense oligonucleotides may target either ICAM-1, VCAM-1 or ELAM-1 in the assay.

[0058] An example of the effects of antisense oligonucleotides targeting ICAM-1 mRNA on the adherence of DMSO differentiated HL-60 cells to tumor necrosis factor treated human umbilical vein endothelial cells is shown in Figure 7. Human umbilical vein endothelial cells were grown to 80% confluence in 12 well plates. The cells were treated with 2 µM oligonucleotide diluted in Opti-MEM containing 8 µM DOTMA for 4 hours at 37°C. The medium was removed and replaced with fresh endothelial cell growth medium (EGM-UV) containing 2 µM of the indicated oligonucleotide and incubated 4 hours at 37°C. Tumor necrosis factor, 1 ng/ml, was added to cells as indicated and cells incubated for an additional 19 hours. The cells were washed once with EGM-UV and 1.6 x 10⁶ HL-60 cells differentiated for 4 days with 1.3% DMSO added. The cells were allowed to attach for 1 hour at 37°C and gently washed 4 times with Dulbecco's phosphate-buffered saline (D-PBS) warmed to 37°C. Adherent cells were detached from the monolayer by addition of 0.25 ml of cold (4°C) phosphate-buffered saline containing 5 mM EDTA and incubated on ice for 5 minutes. The number of cells removed by treatment with EDTA was determined by counting with a hemocytometer. Endothelial cells detached from the monolayer by EDTA treatment could easily be distinguished from HL-60 cells by morphological differences.

[0059] In the absence of tumor necrosis factor, 3% of the HL-60 cells bound to the endothelial cells. Treatment of the endothelial cell monolayer with 1 ng/ml tumor necrosis factor increased the number of adhering cells to 59% of total cells added (Figure 7). Treatment with the antisense oligonucleotide COMPOUND 2 or the control oligonucleotide COMPOUND 5 did not change the number of cells adhering to the monolayer in the absence of tumor necrosis factor treatment (Figure 7). The antisense oligonucleotide, COMPOUND 2 reduced the number of adhering cells from 59% of total cells added to 17% of the total cells added (Figure 7). In contrast, the control oligonucleotide COMPOUND 5 did not significantly reduce the number of cells adhering to the tumor necrosis factor treated endothelial monolayer, i. e., 53% of total cells added for COMPOUND 5 treated cells versus 59% for control cells.

[0060] These data indicate that antisense oligonucleotides are capable of inhibiting ICAM-1 expression on endothelial cells and that inhibition of ICAM-1 expression correlates with a decrease in the adherence of a neutrophil-like cell to the endothelial monolayer in a sequence specific fashion. Because other molecules also mediate adherence of white blood cells to endothelial cells, such as ELAM-1, and VCAM-1 it is not expected that adherence would be completely blocked.

Example 3**Synthesis and characterization of oligonucleotides**

[0061] Unmodified DNA oligonucleotides were synthesized on an automated DNA synthesizer (Applied Biosystems model 380B) using standard phosphoramidite chemistry with oxidation by iodine. β-cyanoethyl-diisopropyl-phosphoramidites were purchased from Applied Biosystems (Foster City, CA). For phosphorothioate oligonucleotides, the standard oxidation bottle was replaced by a 0.2 M solution of 3H-1,2-benzodithiole-3-one 1,1-dioxide in acetonitrile for the stepwise thiation of the phosphite linkages. The thiation cycle wait step was increased to 68 seconds and was followed by the capping step.

[0062] 2'-O-methyl phosphorothioate oligonucleotides were synthesized using 2'-O-methyl β-cyanoethyl-diisopropyl-phosphoramidites (Chemgenes, Needham MA) and the standard cycle for unmodified oligonucleotides, except the wait step after pulse delivery of tetrazole and base was increased to 360 seconds. The 3'-base used to start the synthesis was a 2'-deoxyribonucleotide.

[0063] 2'-fluoro phosphorothioate oligonucleotides were synthesized using 5'-dimethoxytrityl-3'-phosphoramidites and prepared as disclosed in U.S. patent application Serial No. 463,358, filed January 11, 1990, and 566,977, filed August 13, 1990, which are assigned to the same assignee as the instant application and which are incorporated by reference herein. The 2'-fluoro oligonucleotides were prepared using phosphoramidite chemistry and a slight modification of the standard DNA synthesis protocol: deprotection was effected using methanolic ammonia at room temperature.

[0064] After cleavage from the controlled pore glass column (Applied Biosystems) and deblocking in concentrated ammonium hydroxide at 55°C for 18 hours, the oligonucleotides were purified by precipitation twice out of 0.5 M NaCl with 2.5 volumes ethanol. Analytical gel electrophoresis was accomplished in 20% acrylamide, 8 M urea, 45 mM Tris-

borate buffer, pH 7.0. Oligodeoxynucleotides and phosphorothioate oligonucleotides were judged from electrophoresis to be greater than 80% full length material.

[0065] RNA oligonucleotide synthesis was performed on an ABI model 380B DNA synthesizer. The standard synthesis cycle was modified by increasing the wait step after the pulse delivery of tetrazole to 900 seconds. The bases were deprotected by incubation in methanolic ammonia overnight. Following base deprotections the oligonucleotides were dried *in vacuo*. The t-butyldimethylsilyl protecting the 2' hydroxyl was removed by incubating the oligonucleotide in 1 M tetrabutylammonium-fluoride in tetrahydrofuran overnight. The RNA oligonucleotides were further purified on C₁₈ Sep-Pak cartridges (Waters, Division of Millipore Corp., Milford MA) and ethanol precipitated.

[0066] The relative amounts of phosphorothioate and phosphodiester linkages obtained by this synthesis were periodically checked by ³¹P NMR spectroscopy. The spectra were obtained at ambient temperature using deuterium oxide or dimethyl sulfoxide-d₆ as solvent. Phosphorothioate samples typically contained less than one percent of phosphodiester linkages.

[0067] Secondary evaluation was performed with oligonucleotides purified by trityl-on HPLC on a PRP-1 column (Hamilton Co., Reno, Nevada) using a gradient of acetonitrile in 50 mM triethylammonium acetate, pH 7.0 (4% to 32% in 30 minutes, flow rate = 1.5 ml/min). Appropriate fractions were pooled, evaporated and treated with 5% acetic acid at ambient temperature for 15 minutes. The solution was extracted with an equal volume of ethyl acetate, neutralized with ammonium hydroxide, frozen and lyophilized. HPLC-purified oligonucleotides were not significantly different in potency from precipitated oligonucleotides, as judged by the ELISA assay for ICAM-1 expression.

Example 4

Cell culture and treatment with oligonucleotides

[0068] The human lung carcinoma cell line A549 was obtained from the American Type Culture Collection (Bethesda MD). Cells were grown in Dulbecco's Modified Eagle's Medium (Irvine Scientific, Irvine CA) containing 1 gm glucose/liter and 10% fetal calf serum (Irvine Scientific). Human umbilical vein endothelial cells (HUVEC) (Clonetics, San Diego CA) were cultured in EGM-UV medium (Clonetics). HUVEC were used between the second and sixth passages. Human epidermal carcinoma A431 cells were obtained from the American Type Culture Collection and cultured in DMEM with 4.5 g/l glucose. Primary human keratinocytes were obtained from Clonetics and grown in KGM (Keratinocyte growth medium, Clonetics).

[0069] Cells grown in 96-well plates were washed three times with Opti-MEM (GIBCO, Grand Island, NY) prewarmed to 37°C. 100 µl of Opti-MEM containing either 10 µg/ml N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethylammonium chloride (DOTMA, Bethesda Research Labs, Bethesda MD) in the case of HUVEC cells or 20 µg/ml DOTMA in the case of A549 cells was added to each well. Oligonucleotides were sterilized by centrifugation through 0.2 µm Centrex cellulose acetate filters (Schleicher and Schuell, Keene, NH). Oligonucleotides were added as 20x stock solution to the wells and incubated for 4 hours at 37°C. Medium was removed and replaced with 150 µl of the appropriate growth medium containing the indicated concentration of oligonucleotide. Cells were incubated for an additional 3 to 4 hours at 37°C then stimulated with the appropriate cytokine for 14 to 16 hours, as indicated. ICAM-1 expression was determined as described in Example 1. The presence of DOTMA during the first 4 hours incubation with oligonucleotide increased the potency of the oligonucleotides at least 100-fold. This increase in potency correlated with an increase in cell uptake of the oligonucleotide.

Example 5

ELISA screening of additional antisense oligonucleotides for activity against ICAM-1 gene expression in Interleukin-1β-stimulated cells

[0070] Antisense oligonucleotides were originally designed that would hybridize to five target sites on the human ICAM-1 mRNA. Oligonucleotides were synthesized in both phosphodiester (P=O; ISIS 1558, 1559, 1563, 1564 and 1565) and phosphorothioate (P=S; ISIS 1570, 1571, 1572, 1573, and 1574) forms. The oligonucleotides are shown in Table 1.

TABLE 1

ANTISENSE OLIGONUCLEOTIDES WHICH TARGET HUMAN ICAM-1			
ISIS NO.	SEQ ID NO.	TARGET REGION	MODIFICATION
1558	1	AUG Codon (64-81)	P=O

TABLE 1 (continued)

ANTISENSE OLIGONUCLEOTIDES WHICH TARGET HUMAN ICAM-1			
ISIS NO.	SEQ ID NO.	TARGET REGION	MODIFICATION
1559	2	5'-Untranslated (32-49)	P=O
1563	3	3'-Untranslated (2190-3010)	P=O
1564	4	3'-Untranslated (2849-2866)	P=O
1565	5	Coding Region (1378-1395)	P=O
1570	1	AUG Codon (64-81)	P=S
1571	2	5'-Untranslated (32-49)	P=S
1572	3	3'-Untranslated (2190-3010)	P=S
1573	4	3'-Untranslated (2849-2866)	P=S
1574	5	Coding Region (1378-1395)	P=S
1930	6	5'-Untranslated (1-20)	P=S
1931	7	AUG Codon (55-74)	P=S
1932	8	AUG Codon (72-91)	P=S
1933	9	Coding Region (111-130)	P=S
1934	10	Coding Region (351-370)	P=S
1935	11	Coding Region (889-908)	P=S
1936	12	Coding Region (1459-1468)	P=S
1937	13	Termination Codon (1651-1687)	P=S
1938	14	Termination Codon (1668-1687)	P=S
1939	15	3'-Untranslated (1952-1971)	P=S
1940	16	3'-Untranslated (2975-2994)	P=S
2149	17	AUG Codon (64-77)	P=S
2163	18	AUG Codon (64-75)	P=S
2164	19	AUG Codon (64-73)	P=S
2165	20	AUG Codon (66-80)	P=S
2173	21	AUG Codon (64-79)	P=S
2302	22	3'-Untranslated (2114-2133)	P=S
2303	23	3'-Untranslated (2039-2058)	P=S
2304	24	3'-Untranslated (1895-1914)	P=S
2305	25	3'-Untranslated (1935-1954)	P=S
2307	26	3'-Untranslated (1976-1995)	P=S
2634	1	AUG-Codon (64-81)	2'-fluoro A,C & U; P=S
2637	15	3'-Untranslated (1952-1971)	2'-fluoro A, C & U;
2691	1	AUG Codon (64-81)	P=O, except last 3 bases, P=S
2710	15	3'-Untranslated (1952-1971)	2' - O - methyl; P=O
2711	1	AUG Codon (64-81)	2' - O - methyl; P=O
2973	15	3'-Untranslated (1952-1971)	2' - O - methyl; P=S
2974	1	AUG Codon (64-81)	2' - O - methyl; P=S
3064	27	5'-CAP (32-51)	P=S; G & C added as spacer to 3'
3067	84	5'-CAP (32-51)	P=S
3222	84	5'-CAP (32-51)	2' - O - methyl; P=O
3224	84	5'-CAP (32-51)	2' - O - methyl; P=S
3581	85	3'-Untranslated (1959-1978)	P=S

[0071] Inhibition of ICAM-1 expression on the surface of interleukin-1 β -stimulated cells by the oligonucleotides was determined by ELISA assay as described in Example 1. The oligonucleotides were tested in two different cell lines. None of the phosphodiester oligonucleotides inhibited ICAM-1 expression. This is probably due to the rapid degradation of phosphodiester oligonucleotides in cells. Of the five phosphorothioate oligonucleotides, the most active was ISIS 1570, which hybridizes to the AUG translation initiation codon. A 2'-o-methyl phosphorothioate oligonucleotide, ISIS 2974, was approximately threefold less effective than ISIS 1570 in inhibiting ICAM-1 expression in HUVEC and A549

cells. A 2'-fluoro oligonucleotide, ISIS 2634, was also less effective.

[0072] Based on the initial data obtained with the five original targets, additional oligonucleotides were designed which would hybridize with the ICAM-1 mRNA. The antisense oligonucleotide (ISIS 3067) which hybridizes to the predicted transcription initiation site (5' cap site) was approximately as active in IL-1 β -stimulated cells as the oligonucleotide that hybridizes to the AUG codon (ISIS 1570), as shown in Figure 8. ISIS 1931 and 1932 hybridize 5' and 3', respectively, to the AUG translation initiation codon. All three oligonucleotides that hybridize to the AUG region inhibit ICAM-1 expression, though ISIS 1932 was slightly less active than ISIS 1570 and ISIS 1931. Oligonucleotides which hybridize to the coding region of ICAM-1 mRNA (ISIS 1933, 1934, 1935, 1574 and 1936) exhibited weak activity. Oligonucleotides that hybridize to the translation termination codon (ISIS 1937 and 1938) exhibited moderate activity.

[0073] Surprisingly, the most active antisense oligonucleotide was ISIS 1939, a phosphorothioate oligonucleotide targeted to a sequence in the 3'- untranslated region of ICAM-1 mRNA (see Table 1). Other oligonucleotides having the same sequence were tested, 2'-O-methyl (ISIS 2973) and 2'-fluoro (ISIS 2637); however, they did not exhibit this level of activity. Oligonucleotides targeted to other 3' untranslated sequences (ISIS 1572, 1573 and 1940) were also not as active as ISIS-1939. In fact, ISIS 1940, targeted to the polyadenylation signal, did not inhibit ICAM-1 expression.

[0074] Because ISIS 1939 proved unexpectedly to exhibit the greatest antisense activity of the original 16 oligonucleotides tested, other oligonucleotides were designed to hybridize to sequences in the 3'-untranslated region of ICAM-1 mRNA (ISIS 2302, 2303, 2304, 2305, and 2307, as shown in Table 1). ISIS 2307, which hybridizes to a site only five bases 3' to the ISIS 1939 target, was the least active of the series (Figure 8). ISIS 2302, which hybridizes to the ICAM-1 mRNA at a position 143 bases 3' to the ISIS 1939 target, was the most active of the series, with activity comparable to that of ISIS 1939. Examination of the predicted RNA secondary structure of the human ICAM-1 mRNA 3'-untranslated region (according to M. Zuker, *Science* **1989**, 244, 48-52) revealed that both ISIS 1939 and ISIS 2302 hybridize to sequences predicted to be in a stable stem-loop structure. Current dogma suggests that regions of RNA secondary structure should be avoided when designing antisense oligonucleotides. Thus, ISIS 1939 and ISIS 2302 would not have been predicted to inhibit ICAM-1 expression.

[0075] The control oligonucleotide ISIS 1821 did inhibit ICAM-1 expression in HUVEC cells with activity comparable to that of ISIS 1934; however, in A549 cells ISIS 1821 was less effective than ISIS 1934. The negative control, ISIS 1821, was found to have a small amount of activity against ICAM expression, probably due in part to its ability to hybridize (12 of 13 base match) to the ICAM-1 mRNA at a position 15 bases 3' to the AUG translation initiation codon.

[0076] These studies indicate that the AUG translation initiation codon and specific 3'-untranslated sequences in the ICAM-1 mRNA were the most susceptible to antisense oligonucleotide inhibition of ICAM-1 expression.

[0077] In addition to inhibiting ICAM-1 expression in human umbilical vein cells and the human lung carcinoma cells (A549), ISIS 1570, ISIS 1939 and ISIS 2302 were shown to inhibit ICAM-1 expression in the human epidermal carcinoma A431 cells and in primary human keratinocytes (shown in Figure 9). These data demonstrate that antisense oligonucleotides are capable of inhibiting ICAM-1 expression in several human cell lines. Furthermore, the rank order potency of the oligonucleotides is the same in the four cell lines examined. The fact that ICAM-1 expression could be inhibited in primary human keratinocytes is important because epidermal keratinocytes are an intended target of the antisense nucleotides.

Example 6

ELISA screening of antisense oligonucleotides for activity against ELAM-1 gene expression

[0078] Primary human umbilical vein endothelial (HUVEC) cells, passage 2 to 5, were plated in 96-well plates and allowed to reach confluence. Cells were washed three times with Opti-MEM (GIBCO, Grand Island NY). Cells were treated with increasing concentrations of oligonucleotide diluted in Opti-MEM containing 10 μ g/ml DOTMA solution (Bethesda Research Labs, Bethesda MD) for 4 hours at 37°C. The medium was removed and replaced with EGM-UV (Clonetics, San Diego CA) plus oligonucleotide. Tumor necrosis factor α was added to the medium (2.5 ng/ml) and the cells were incubated an additional 4 hours at 37°C.

[0079] ELAM-1 expression was determined by ELISA. Cells were gently washed three times with Dulbecco's phosphate-buffered saline (D-PBS) prewarmed to 37°C. Cells were fixed with 95% ethanol at 4°C for 20 minutes, washed three times with D-PBS and blocked with 2% BSA in D-PBS. Cells were incubated with ELAM-1 monoclonal antibody BBA-1 (R&D Systems, Minneapolis MN) diluted to 0.5 μ g/ml in D-PBS containing 2% BSA for 1 hour at 37°C. Cells were washed three times with D-PBS and the bound ELAM-1 antibody detected with biotinylated goat anti-mouse secondary antibody followed by β -galactosidase-conjugated streptavidin as described in Example 1.

[0080] The activity of antisense phosphorothioate oligonucleotides which target 11 different regions on the ELAM-1 cDNA and two oligonucleotides which target ICAM-1 (as controls) was determined using the ELAM-1 ELISA. The oligonucleotide and targets are shown in Table 2.

TABLE 2

ANTISENSE OLIGONUCLEOTIDES WHICH TARGET HUMAN ELAM-1			
ISIS NO.	SEQ ID NO.	TARGET REGION	MODIFICATION
1926	28	AUG Codon (143-164)	P=S
2670	29	3'-Untranslated (3718-3737)	P=S
2673	30	3'-Untranslated (2657-2677)	P=S
2674	31	3'-Untranslated (2617-2637)	P=S
2678	32	3'-Untranslated (3558-3577)	P=S
2679	33	5'-Untranslated (41-60)	P=S
2680	34	3'-Untranslated (3715-3729)	P=S
2683	35	AUG Codon (143-163)	P=S
2686	36	AUG Codon (149-169)	P=S
2687	37	5'-Untranslated (18-37)	P=S
2693	38	3'-Untranslated (2760-2788)	P=S
2694	39	3'-Untranslated (2934-2954)	P=S

[0081] In contrast to what was observed with antisense oligonucleotides targeted to ICAM-1 (Example 5), the most potent oligonucleotide modulator of ELAM-1 activity (ISIS 2679) was hybridizable with specific sequences in the 5'-untranslated region of ELAM-1. ISIS 2687, an oligonucleotide which hybridized to sequences ending three bases upstream of the ISIS 2679 target, did not show significant activity (Figure 10). Therefore, ISIS 2679 hybridizes to a unique site on the ELAM-1 mRNA, which is uniquely sensitive to inhibition with antisense oligonucleotides. The sensitivity of this site to inhibition with antisense oligonucleotides was not predictable based upon RNA secondary structure predictions or information in the literature.

Example 7

ELISA screening of antisense oligonucleotides for activity against VCAM-1 gene expression

[0082] Inhibition of VCAM-1 expression by fifteen antisense phosphorothioate oligonucleotides was determined using the ELISA assay approximately as described in Representative Example 6, except that cells were stimulated with TNF- α for 16 hours and VCAM-1 expression was detected by a VCAM-1 specific monoclonal antibody (R & D Systems, Minneapolis, MN) used at 0.5 μ g/ml. The target sites of these oligonucleotides on the VCAM-1 mRNA are shown in Figure 11. The sequence and activity of each oligonucleotide against VCAM-1 are shown in Table 3. The oligonucleotides indicated by an asterisk (*) have IC₅₀'s of approximately 50 nM or below and are preferred. IC₅₀ indicates the dosage of oligonucleotide which results in 50% inhibition of VCAM-1 expression.

TABLE 3

Inhibition of human VCAM-1 expression by antisense oligonucleotides
VCAM-1 expression is given as % of control

ISIS#	SEQ ID NO:	POSITION	SEQUENCE	VCAM-1 EXPRESSION	
				30 nM oligo	50 nM oligo
*5884	60	5'-UTR	CGATGCAGATACCGGGAGT	79.2	37.2
3791	61	5'-UTR	GCCTGGGAGGGTATTCAGCT	92.6	58.0
5862	62	5'-UTR	CCTGTGTGTCCTGGGAGGG	115.0	83.5
*3792	63	AUG	GGCATTTTAAAGTTGCTGTCG	68.7	33.7
5863	64	CODING	CAGCCTGCCTTACTGTGGSC	95.8	66.7
*5874	65	CODING	CTTGAACAATAATCCACCT	66.5	35.3
5885	66	E/I	TTACCATTGACATAAAGTGTT	84.4	52.4
*5876	67	CODING	CTGTGTCCTCCTGCTCCGCT	43.5	26.6
*5875	68	CODING	GTCTTTGTTGTTTCTCTTCC	59.2	34.8
3794	69	TERMIN.	TGAACATATCAAGCATTAGC	75.3	52.6
*3800	70	3'-UTR	GCAATCTTGCTATGGCATAA	64.4	47.7
*3805	71	3'-UTR	CCCGGCATCTTTACAAAACC	67.7	44.9
*3801	50	3'-UTR	AACCCAGTGCTCCCTTTGCT	36.5	21.3
*5847	72	3'-UTR	AACATCTCCGTACCATGCCA	51.8	24.6
*3804	51	3'-UTR	GGCCACATTGGGAAAGTTGC	55.1	29.3

E/I indicates exon/intron junction
Oligonucleotides with IC50's of approximately 50 nM or below are indicated by an asterisk (*).

SEQUENCE LISTING

[0083]

5 (1) GENERAL INFORMATION:

(i) APPLICANT: Bennett and Mirabelli

(ii) TITLE OF INVENTION: Oligonucleotide Modulation of Cell Adhesion

10 (iii) NUMBER OF SEQUENCES: 85

(iv) CORRESPONDENCE ADDRESS:

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 (B) STREET: 210 Lake Drive East, Suite 201
 (C) CITY: Cherry Hill
 (D) STATE: NJ
 (E) COUNTRY: USA
 20 (F) ZIP: 08002

(v) COMPUTER READABLE FORM:

25 (A) MEDIUM TYPE: DISKETTE, 3.5 INCH, 1.44 Mb STORAGE
 (B) COMPUTER: IBM PS/2
 (C) OPERATING SYSTEM: PC-DOS
 (D) SOFTWARE: WORDPERFECT 5.0

(vi) CURRENT APPLICATION DATA:

30 (A) APPLICATION NUMBER: n/a
 (B) FILING DATE: Herewith
 (C) CLASSIFICATION:

(vii) PRIOR APPLICATION DATA:

35 (A) APPLICATION NUMBER: 939,855
 (B) FILING DATE: September 2, 1992

(vii) PRIOR APPLICATION DATA:

40 (A) APPLICATION NUMBER: PCT/US91/05209
 (B) FILING DATE: July 23, 1991

(vii) PRIOR APPLICATION DATA:

45 (A) APPLICATION NUMBER: 567,286
 (B) FILING DATE: August 14, 1990

(vii) PRIOR APPLICATION DATA:

50 (A) APPLICATION NUMBER: 007,997
 (B) FILING DATE: January 20, 1993

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- 5 (A) TELEPHONE: (609) 779-2400
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(2) INFORMATION FOR SEQ ID NO:1:

10 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 18
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
15 (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

20 **TGGGAGCCAT AGCGAGGC**

18

(2) INFORMATION FOR SEQ ID NO: 2:

25 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
30 (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:

35 **GAGGAGCTCA GCGTCGACTG**

20

(2) INFORMATION FOR SEQ ID NO: 3:

40 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
45 (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 3:

50 **GACACTCAAT AAATAGCTGG T**

21

(2) INFORMATION FOR SEQ ID NO: 4:

55 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 18
(B) TYPE: Nucleic Acid

(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 4:

GAGGCTGAGG TGGGAGGA

18

(2) INFORMATION FOR SEQ ID NO: 5:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 18

(B) TYPE: Nucleic Acid

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 5:

CGATGGGCAG TGGGAAAG

18

(2) INFORMATION FOR SEQ ID NO: 6:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 6:

GGGCGCGTGA TCCTTATAGC

20

(2) INFORMATION FOR SEQ ID NO: 7:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 7:

CATAGCGAGG CTGAGGTTGC

20

(2) INFORMATION FOR SEQ ID NO: 8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

5

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 8:

10

CGGGGGCTGC TGGGAGCCAT

20

(2) INFORMATION FOR SEQ ID NO: 9:

(i) SEQUENCE CHARACTERISTICS:

15

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

20

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 9:

25

AGAGCCCCGA GCAGGACCAG

20

(2) INFORMATION FOR SEQ ID NO: 10:

(i) SEQUENCE CHARACTERISTICS:

30

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

35

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 10:

40

TGCCCCATCAG GGCAGTTTGA

20

(2) INFORMATION FOR SEQ ID NO: 11:

(i) SEQUENCE CHARACTERISTICS:

45

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

50

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 11:

55

GGTCACACTG ACTGAGGCCT

20

(2) INFORMATION FOR SEQ ID NO: 12:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 12:

CTCGCGGGTG ACCTCCCCTT

20

(2) INFORMATION FOR SEQ ID NO: 13:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 13:

TCAGGGAGGC GTGGCTTGTG

20

(2) INFORMATION FOR SEQ ID NO: 14:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 14:

CCTGTCCCGG GATAGGTTC A

20

(2) INFORMATION FOR SEQ ID NO: 15:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 15:

CCCCACCAC TTCCCCTCTC

20

(2) INFORMATION FOR SEQ ID NO: 16:

(i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 10 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 16:

TTGAGAAAGC TTTATTAAC

20

15

(2) INFORMATION FOR SEQ ID NO: 17:

(i) SEQUENCE CHARACTERISTICS:

- 20 (A) LENGTH: 14
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 25 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 17:

AGCCATAGCG AGGC

14

30

(2) INFORMATION FOR SEQ ID NO: 18:

(i) SEQUENCE CHARACTERISTICS:

- 35 (A) LENGTH: 12
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 40 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 18:

CCATAGCGAG GC

12

45

(2) INFORMATION FOR SEQ ID NO: 19:

(i) SEQUENCE CHARACTERISTICS:

- 50 (A) LENGTH: 10
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 55 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 19:

ATAGCGAGGC**10**

(2) INFORMATION FOR SEQ ID NO: 20:

5

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 16

(B) TYPE: Nucleic Acid

10

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 20:

15

TGGGAGCCAT AGCGAG**16**

(2) INFORMATION FOR SEQ ID NO: 21:

20

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 16

(B) TYPE: Nucleic Acid

25

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 21:

30

GGAGCCATAG CGAGGC**16**

(2) INFORMATION FOR SEQ ID NO: 22:

35

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

40

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 22:

45

GCCCAAGCTG GCATCCGTCA**20**

(2) INFORMATION FOR SEQ ID NO: 23:

50

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

55

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 23:

TCTGTAAGTC TGTGGGCCTC

20

5

(2) INFORMATION FOR SEQ ID NO: 24:

(i) SEQUENCE CHARACTERISTICS:

10

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

15

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 24:

AGTCTTGCTC CTCCTCTTG

20

20

(2) INFORMATION FOR SEQ ID NO: 25:

(i) SEQUENCE CHARACTERISTICS:

25

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

30

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 25:

CTCATCAGGC TAGACTTTAA

20

35

(2) INFORMATION FOR SEQ ID NO: 26:

(i) SEQUENCE CHARACTERISTICS:

40

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

45

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 26:

TGTCCTCATG GTGGGGCTAT

20

50

(2) INFORMATION FOR SEQ ID NO: 27:

(i) SEQUENCE CHARACTERISTICS:

55

- (A) LENGTH: 22
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 27:

5 **TCTGAGTAGC AGAGGAGCTC GA** 22

(2) INFORMATION FOR SEQ ID NO: 28:

10 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 22
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 28:

20 **CAATCATGAC TTCAAGAGTT CT** 22

(2) INFORMATION FOR SEQ ID NO: 29:

25 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 29:

35 **ACCACACTGG TATTTACAC** 20

(2) INFORMATION FOR SEQ ID NO: 30:

40 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 30:

50 **GTATGGAAGA TTATAATATA T** 21

(2) INFORMATION FOR SEQ ID NO: 31:

55 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 31:

5

CACAATCCTT AAGAACTCTT T

21

(2) INFORMATION FOR SEQ ID NO: 32:

10

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

15

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 32:

20

ACCTCTGCTG TTCTGATCCT

20

(2) INFORMATION FOR SEQ ID NO: 33:

25

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

30

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 33:

35

CTGCTGCCTC TGTCTCAGGT

20

(2) INFORMATION FOR SEQ ID NO: 34:

40

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 15

(B) TYPE: Nucleic Acid

45

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 34:

50

GGTATTTGAC ACAGC

15

(2) INFORMATION FOR SEQ ID NO: 35:

55

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 21

(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

5 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 35:

AATCATGACT TCAAGAGTTC T

21

10 (2) INFORMATION FOR SEQ ID NO: 36:

(i) SEQUENCE CHARACTERISTICS:

15 (A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

20 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 36:

TGAAGCAATC ATGACTTCAA G

21

25 (2) INFORMATION FOR SEQ ID NO: 37:

(i) SEQUENCE CHARACTERISTICS:

30 (A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

35 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 37:

TATAGGAGTT TTGATGTGAA

20

40 (2) INFORMATION FOR SEQ ID NO: 38:

(i) SEQUENCE CHARACTERISTICS:

45 (A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

50 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 38:

ACAATGAGGG GGTAATCTAC A

21

55 (2) INFORMATION FOR SEQ ID NO: 39:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

5

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 39:

10

GACAATATAC AAACCTTCCA T

21

- (2) INFORMATION FOR SEQ ID NO: 40:

15

- (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

20

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 40:

25

CCAGGCATTT TAAGTTGCTG T

21

- (2) INFORMATION FOR SEQ ID NO: 41:

30

- (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

35

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 41:

40

CCTGAAGCCA GTGAGGCCCG

20

- (2) INFORMATION FOR SEQ ID NO: 42:

45

- (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

50

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 42:

55

GATGAGAAAA TAGTGAACC A

21

- (2) INFORMATION FOR SEQ ID NO: 43:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 19
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 43:

CTGAGCAAGA TATCTAGAT

19

(2) INFORMATION FOR SEQ ID NO: 44:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 19
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 44:

CTACACTTTT GATTTCTGT

19

(2) INFORMATION FOR SEQ ID NO: 45:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 22
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 45:

TTGAACATAT CAAGCATTAG CT

22

(2) INFORMATION FOR SEQ ID NO: 46:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 22
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 46:

TTTACATATG TACAAATTAT GT

22

(2) INFORMATION FOR SEQ ID NO: 47:

(i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 22
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 10 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 47:

AATTATCACT TTACTATACA AA

22

(2) INFORMATION FOR SEQ ID NO: 48:

(i) SEQUENCE CHARACTERISTICS:

- 20 (A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 25 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 48:

AGGGCTGACC AAGACGTTG T

21

(2) INFORMATION FOR SEQ ID NO: 49:

(i) SEQUENCE CHARACTERISTICS:

- 35 (A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 40 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 49:

CCATCTTCCC AGGCATTTTA

20

(2) INFORMATION FOR SEQ ID NO: 50:

(i) SEQUENCE CHARACTERISTICS:

- 50 (A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 55 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 50:

AACCCAGTGC TCCCTTTGCT**20**

(2) INFORMATION FOR SEQ ID NO: 51:

5

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

10

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 51:

15

GGCCACATTG GGAAAGTTGC**20**

(2) INFORMATION FOR SEQ ID NO: 52:

20

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

25

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 52:

30

GAAGTCAGCC AAGAACAGCT**20**

(2) INFORMATION FOR SEQ ID NO: 53:

35

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

40

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 53:

45

ACAGGATCTC TCAGGTGGGT**20**

(2) INFORMATION FOR SEQ ID NO: 54:

50

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

55

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 54:

CCAAAGTGAG AGCTGAGAGA

20

5

(2) INFORMATION FOR SEQ ID NO: 55:

(i) SEQUENCE CHARACTERISTICS:

10

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

15

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 55:

CTGATTCAAG GCTTTGGCAG

20

20

(2) INFORMATION FOR SEQ ID NO: 56:

(i) SEQUENCE CHARACTERISTICS:

25

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

30

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 56:

TTCCCCAGAT GCACCTGTTT

20

35

(2) INFORMATION FOR SEQ ID NO: 57:

(i) SEQUENCE CHARACTERISTICS:

40

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

45

- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 57:

GGGCCAGAGA CCCGAGGAGA

20

50

(2) INFORMATION FOR SEQ ID NO: 58:

(i) SEQUENCE CHARACTERISTICS:

55

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 58:

5 ACGTTTGGCC TCATGGAAGT 20

(2) INFORMATION FOR SEQ ID NO: 59:

(i) SEQUENCE CHARACTERISTICS:

10

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

15 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 59:

20 GGAATGCAA GCACATCCAT 20

(2) INFORMATION FOR SEQ ID NO: 60:

(i) SEQUENCE CHARACTERISTICS:

25

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

30 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 60:

CGATGCAGAT ACCGCGGAGT 20

(2) INFORMATION FOR SEQ ID NO: 61:

(i) SEQUENCE CHARACTERISTICS:

40

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

45 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 61:

50 GCCTGGGAGG GTATTCAGCT 20

(2) INFORMATION FOR SEQ ID NO: 62:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 62:

5

CCTGTGTGTG CCTGGGAGGG

20

(2) INFORMATION FOR SEQ ID NO: 63:

10

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

15

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 63:

20

GGCATTTTAA GTTGCTGTCG

20

(2) INFORMATION FOR SEQ ID NO: 64:

25

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 20

(B) TYPE: Nucleic Acid

30

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 64:

35

CAGCCTGCCT TACTGTGGGC

20

(2) INFORMATION FOR SEQ ID NO: 65:

40

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 21

(B) TYPE: Nucleic Acid

45

(C) STRANDEDNESS: Single

(D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 65:

50

CTTGAACAAT TAATTCCACC T

21

(2) INFORMATION FOR SEQ ID NO: 66:

55

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 21

(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

5 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 66:

TTACCATTGA CATAAAGTGT T

21

10

(2) INFORMATION FOR SEQ ID NO: 67:

(i) SEQUENCE CHARACTERISTICS:

15

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

20

(iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 67:

CTGTGTCTCC TGTCTCCGCT

20

25

(2) INFORMATION FOR SEQ ID NO: 68:

(i) SEQUENCE CHARACTERISTICS:

30

(A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

35

(iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 68:

GTCTTTGTTG TTTTCTCTTCC

21

40

(2) INFORMATION FOR SEQ ID NO: 69:

(i) SEQUENCE CHARACTERISTICS:

45

(A) LENGTH: 20
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

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(iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 69:

TGAACATATC AAGCATTAGC

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(2) INFORMATION FOR SEQ ID NO: 70:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

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- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 70:

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GCAATCTTGC TATGGCATAA

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(2) INFORMATION FOR SEQ ID NO: 71:

(i) SEQUENCE CHARACTERISTICS:

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- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

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- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 71:

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CCCGGCATCT TTACAAAACC

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(2) INFORMATION FOR SEQ ID NO: 72:

(i) SEQUENCE CHARACTERISTICS:

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- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

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- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 72:

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AACATCTCCG TACCATGCCA

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(2) INFORMATION FOR SEQ ID NO: 73:

(i) SEQUENCE CHARACTERISTICS:

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- (A) LENGTH: 22
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

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- (iv) ANTI-SENSE: Yes
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 73:

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TCACTGCTGC CTCTGTCTCA GG

22

(2) INFORMATION FOR SEQ ID NO: 74:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 23
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 74:

TGATTCTTTT GAACTTAAAA GGA

23

(2) INFORMATION FOR SEQ ID NO: 75:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 75:

TTAAAGGATG TAAGAAGGCT

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(2) INFORMATION FOR SEQ ID NO: 76:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 19
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 76:

CATAAGCACA TTTATTGTC

19

(2) INFORMATION FOR SEQ ID NO: 77:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 77:

TTTTGGGAAG CAGTTGTTCA

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(2) INFORMATION FOR SEQ ID NO: 78:

(i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 21
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 10 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 78:

AACTGTGAAG CAATCATGAC T

21

(2) INFORMATION FOR SEQ ID NO: 79:

(i) SEQUENCE CHARACTERISTICS:

- 20 (A) LENGTH: 22
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 25 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 79:

CCTTGAGTGG TGCATTCAAC CT

22

(2) INFORMATION FOR SEQ ID NO: 80:

(1) SEQUENCE CHARACTERISTICS:

- 35 (A) LENGTH: 22
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 40 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 80:

AATGCTTGCT CACACAGGCA TT

22

(2) INFORMATION FOR SEQ ID NO: 81:

(i) SEQUENCE CHARACTERISTICS:

- 50 (A) LENGTH: 18
(B) TYPE: Nucleic Acid
(C) STRANDEDNESS: Single
(D) TOPOLOGY: Linear

- 55 (iv) ANTI-SENSE: Yes
(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 81:

GCCTCGCTAT GGCTCCCA**18**

(2) INFORMATION FOR SEQ ID NO: 82:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 18
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 82:

CATGGCGCGG GCCGCGGG**18**

(2) INFORMATION FOR SEQ ID NO: 83:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 83:

TGCATCCCCC AGGCCACCAT**20**

(2) INFORMATION FOR SEQ ID NO: 84:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 84:

TCTGAGTAGC AGAGGAGCTC**20**

(2) INFORMATION FOR SEQ ID NO: 85:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20
- (B) TYPE: Nucleic Acid
- (C) STRANDEDNESS: Single
- (D) TOPOLOGY: Linear

(iv) ANTI-SENSE: Yes

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 85:

TATGTCTCCC CCACCACTTC**20**

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Claims

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1. An antisense oligonucleotide having up to 50 nucleotides which inhibits expression of vascular cell adhesion molecule-1, wherein said antisense oligonucleotide comprises the nucleotide sequence shown in SEQ ID NO: 67.

2. The antisense oligonucleotide of claims 1 wherein at least one of the linking groups between nucleotide units comprises a sulfur-containing species.

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3. The antisense oligonucleotide of any one of claims 1 or 2 wherein at least one of the linking groups between nucleotide units comprises a phosphorothioate moiety.

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4. A pharmaceutical composition comprising the antisense oligonucleotide of any one of claims 1 to 3 and a pharmaceutically acceptable carrier.

5. Use of an antisense oligonucleotide according to any one of claims 1 to 3 for the manufacture of a medicament for modulating synthesis of vascular cell adhesion molecule-1 in a cell or tissue.

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6. An antisense oligonucleotide according to any one of claims 1 to 3 for use in treating an animal suspected of having a disease which is modulated by changes in vascular cell adhesion molecule-1.

7. The antisense oligonucleotide of claim 6 wherein the antisense oligonucleotide is administered topically.

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8. The antisense oligonucleotide of claim 6 wherein the antisense oligonucleotide is administered systemically.

9. An antisense oligonucleotide according to any one of claims 1 to 3 for use in decreasing metastasis in an animal suspected of having a metastatic condition.

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10. The antisense oligonucleotide of claim 9 wherein the metastatic is in the lung.

11. The antisense oligonucleotide of any one of the claims 9 or 10 wherein the antisense oligonucleotide is administered in a pharmaceutical composition comprising the antisense oligonucleotide and a pharmaceutically acceptable carrier.

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12. A ex vivo method for modulating synthesis of vascular cell adhesion molecule-1 in a cell or tissue comprising contacting said cell or tissue with an antisense oligonucleotide according to any one of claims 1 to 3.

Patentansprüche

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1. Antisense-Oligonukleotid mit bis zu 50 Nukleotiden, welches die Expression des vaskulären Zelladhäsionsmoleküls-1 (VCAM-1) inhibiert, wobei das Antisense-Oligonukleotid die in SEQ ID Nr. 67 gezeigte Nukleotidsequenz umfaßt.

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2. Antisense-Oligonukleotid nach Anspruch 1, wobei mindestens eine der Verbindungsgruppen zwischen den Nukleotideinheiten eine Schwefelenthaltende Spezies umfaßt.

3. Antisense-Oligonukleotid nach einem der Ansprüche 1 oder 2, wobei mindestens eine der Verbindungsgruppen zwischen den Nukleotideinheiten eine Phosphorothioatkomponente umfaßt.

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4. Pharmazeutische Zusammensetzung, die das Antisense-Oligonukleotid nach einem der Ansprüche 1 bis 3 und einen pharmazeutisch verträglichen Träger umfaßt.

5. Verwendung eines Antisense-Oligonukleotids nach einem der Ansprüche 1 bis 3 für die Herstellung eines Medikaments zur Modulation der Synthese des vaskulären Zelladhäsionsmoleküls-1 in einer Zelle oder einem Gewebe.
6. Antisense-Oligonukleotid nach einem der Ansprüche 1 bis 3 zur Verwendung bei der Behandlung eines Tieres mit Verdacht auf eine Krankheit, die durch Änderungen im vaskulären Zelladhäsionsmolekül-1 moduliert ist.
7. Antisense-Oligonukleotid nach Anspruch 6, wobei das Antisense-Oligonukleotid topisch verabreicht wird.
8. Antisense-Oligonukleotid nach Anspruch 6, wobei das Antisense-Oligonukleotid systemisch verabreicht wird.
9. Antisense-Oligonukleotid nach einem der Ansprüche 1 bis 3 zur Verwendung bei der Verringerung der Metastasierung in einem Tier mit Verdacht auf einen metastasenbildenden Zustand.
10. Antisense-Oligonukleotid nach Anspruch 9, wobei die Metastasenbildung in der Lunge ist.
11. Antisense-Oligonukleotid nach einem der Ansprüche 9 oder 10, wobei das Antisense-Oligonukleotid in einer pharmazeutischen Zusammensetzung verabreicht wird, die das Antisense-Oligonukleotid und einen pharmazeutisch verträglichen Träger umfaßt.
12. *Ex vivo*-Verfahren zur Modulation der Synthese des vaskulären Zelladhäsionsmoleküls-1 in einer Zelle oder einem Gewebe, umfassend das Inkontaktbringen der Zelle oder des Gewebes mit einem Antisense-Oligonukleotid nach einem der Ansprüche 1 bis 3.

Revendications

1. Un oligonucléotide antisens ayant jusqu'à 50 nucléotides, qui inhibe la molécule d'adhésion cellulaire vasculaire 1, dans laquelle cet oligonucléotide antisens comporte la séquence nucléotidique décrite dans le NO 67 ID SEQ.
2. L'oligonucléotide antisens de la revendication 1 dans laquelle l'un au moins des groupes de liaison entre les unités nucléotidiques est constitué d'une espèce soufrée.
3. L'oligonucléotide antisens de l'une quelconque des revendications 1 ou 2, dans laquelle l'un au moins des groupes de liaison entre les unités nucléotidiques est constitué d'un fragment phosphorothioate.
4. Une composition pharmaceutique comprenant l'oligonucléotide antisens de l'une quelconque des revendications 1 à 3 et un véhicule acceptable pharmaceutiquement.
5. Utilisation d'un oligonucléotide antisens selon l'une quelconque des revendications 1 à 3 pour la fabrication d'un médicament destiné à moduler la synthèse de molécule d'adhésion cellulaire vasculaire 1 dans une cellule ou un tissu.
6. Un oligonucléotide antisens selon l'une quelconque des revendications 1 à 3 destiné à être utilisé pour le traitement d'un animal dont on suspecte qu'il a une maladie qui est modulée par des modifications de la molécule d'adhésion cellulaire vasculaire 1.
7. L'oligonucléotide antisens de la revendication 6 dans laquelle l'oligonucléotide antisens est administré de manière topique.
8. L'oligonucléotide antisens de la revendication 6 dans laquelle l'oligonucléotide antisens est administré de manière systémique.
9. Un oligonucléotide antisens selon l'une quelconque des revendications 1 à 3 destiné à être utilisé pour diminuer les métastases chez un animal dont on suspecte qu'il a une pathologie à métastases.
10. L'oligonucléotide antisens de la revendication 9 dans laquelle la métastase est située dans le poumon.
11. L'oligonucléotide antisens de l'une quelconque des revendications 9 ou 10 dans lesquelles l'oligonucléotide anti-

sens est administré dans une composition pharmaceutique comprenant l'oligonucléotide antisens et un véhicule acceptable pharmaceutiquement.

- 5 **12.** Un procédé *ex vivo* pour moduler la synthèse de la molécule d'adhésion cellulaire vasculaire 1 dans une cellule ou un tissu qui consiste en la mise en contact de cette cellule ou de ce tissu avec un oligonucléotide antisens selon l'une quelconque des revendications 1 à 3.

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GCTATAAGGA TCACGGGCCC CAGTCGACGC TGAGCTCCTC TGCTACTCAG AGTTGCAACC TCAGCCTCGCT
 ATG GCT CCC AGC AGC CCC CGG CCC GCG CTG CCC GCA CTC CTG GTC CTG CTC GGG GCT CTG TTC CCA
 MET ALA PRO SER SER PRO ARG PRO ALA LEU PRO ALA LEU LEU VAL LEU LEU GLY ALA LEU PHE PRO
 GGA CCT GGC AAT GCC CAG ACA TCT GTG TCC CCC TCA AAA GTC ATC CTG CCC CGG GGA GGC TCC GTG
 GLY PRO GLY ASN ALA GLN THR SER VAL SER PRO SER LYS VAL ILE LEU PRO ARG GLY GLY SER VAL
 CTG GTG ACA TGC AGC ACC TCC TGT GAC CAG CCC AAG TTG TCG GGC ATA GAG ACC CCG TTG CCT AAA
 LEU VAL THR CYS SER THR SER CYS ASP GLN PRO LYS LEU LEU GLY ILE GLU THR PRO LEU PRO LYS
 AAG GAG TTG CTC CTG CCT GGG AAC AAC CGG AAG GTG TAT GAA CTG AGC AAT GTG CAA GAA GAT AGC
 LYS GLU LEU LEU LEU PRO GLY ASN ASN ARG LYS VAL TYR GLU LEU SER ASN VAL GLN GLU ASP SER
 CAA CCA ATG TGC TAT TCA AAC TGC CCT GAT GGG CAG TCA ACA GCT AAA ACC TTC CTC ACC GTG TAC
 GLN PRO MET CYS TYR SER ASN CYS PRO ASP GLY GLN SER THR ALA LYS THR PHE LEU THR VAL TYR
 TGG ACT CCA GAA CGG GTG GAG GGT GGG GCA CCC CTC CCC TCT TGG CAG CCA GTG GGC AAG AAC CTT ACC
 TRP THR PRO GLU ARG VAL GLU LEU ALA PRO LEU PRO SER TRP GLN PRO VAL GLY LYS ASN LEU THR
 CTA CGC TGC CAG GTG GAG GGT GGG GCA CCC CGG GCC AAC CTC ACC GTG GTG CTC CTG GGG GAG
 LEU ARG CYS GLN VAL GLU GLY GLY ALA PRO ARG ALA ASN LEU THR VAL LEU LEU ARG GLY GLU
 AAG GAG CTG AAA CGG GAG CCA GCT GTG GGG GAG CCC GCT GAG GTC ACC ACC ACG GTG CTG GTG AGG
 LYS GLU LEU LYS ARG GLU PRO ALA VAL GLY GLU PRO ALA GLU VAL THR THR VAL LEU VAL ARG
 AGA GAT CAC CAT GGA GCC AAT TTC TCG TGC CGC ACT GAA CTG GAC CTG CGG CCC CAA GGG CTG GAG
 ARG ASP HIS HIS GLY ALA ASN PHE SER CYS ARG THR GLU LEU ASP LEU ARG PRO GLN GLY LEU GLU

FIG. 1A

CTG TTT GAG AAC ACC TCG GCC GCC TAC CAG CTC CAG ACC TTT GTC CTG CCA GCG ACT CCC CCA CAA
 LEU PHE GLU ASN THR SER ALA PRO TYR GLN LEU GLN THR PHE VAL LEU LEU THR PRO PRO GLN

 CTT GTC AGC CCC CGG GTC CTA GAG GTG GAC ACG CAG GGG ACC ACC GTG GTC TGT TCC CTG GAC GGG CTG
 LEU VAL SER PRO ARG VAL LEU GLU VAL ASP THR GLN GLY THR VAL VAL CYS SER LEU ASP GLY LEU

 TTC CCA GTC TCG GAG GCC CAG GTC CAC CTG GCA CTG GGG GAC CAG AGG TTG AAC CCC ACA GTC ACC
 PHE PRO VAL SER GLU ALA GLN VAL HIS LEU ALA LEU GLY ASP GLN ARG LEU ASN PRO THR VAL THR

 TAT GGC AAC GAC TCC TTC TCG GCC AAG GCC TCA GTC AGT GTG ACC GCA GAG GAC GAG GGC ACC CAG
 TYR GLY ASN ASP SER PHE SER ALA LYS ALA SER VAL SER VAL THR ALA GLU ASP GLU GLY THR GLN

 CGG CTG ACG TGT GCA GTA ATA CTG GGG AAC CAG AGC CAG GAG ACA CTG CAG ACA GTG ACC ATC TAC
 ARG LEU THR CYS ALA VAL ILE LEU GLY ASN GLN SER GLN GLU THR LEU GLN THR VAL THR ILE TYR

 AGC TTT CCG GCG CCC AAC GTG ATT CTG ACG AAG CCA GAG GTC TCA GAA GGG ACC GAG GTG ACA GTG
 SER PHE PRO ALA PRO ASN VAL ILE LEU THR LYS PRO GLU VAL SER GLU GLY THR GLU VAL THR VAL

 AAG TGT GAG GCC CAC CCT AGA GCC AAG GTG ACG CTG AAT GGG GTT CCA GCC CAG CCA CTG GGC CCG
 LYS CYS GLU ALA HIS PRO ARG ALA LYS VAL THR LEU ASN GLY VAL PRO ALA GLN PRO LEU GLY PRO

 AGG GCC CAG CTC CTG AAG GCC ACC CCA GAG GAC AAC GGG CGC AGC TTC TCC TGC TCT GCA ACC
 ARG ALA GLN LEU LEU LYS ALA THR PRO GLU ASP ASN GLY ARG SER PHE SER CYS SER ALA THR

 CTG GAG GTG GCC GGC CAG CTT ATA CAC AAG AAC CAG ACC CGG GAG CTT CGT GTC CTG TAT GGC CCC
 LEU GLU VAL ALA GLY GLN LEU ILE HIS LYS ASN GLN THR ARG GLU LEU ARG VAL LEU TYR GLY PRO

 CGA CTG GAC GAG AGG GAT TGT CCG GGA AAC TGG ACG TGG CCA GAA AAT TCC CAG CAG ACT CCA ATG
 ARG LEU ASP GLU ARG ASP CYS PRO GLY ASN TRP THR TRP PRO GLU ASN SER GLN GLN THR PRO MET

 TGC CAG GCT TGG GGG AAC CCA TTG CCC GAG CTC AAG TGT CTA AAG GAT GGC ACT TTC CCA CTG CCC
 CYS GLN ALA TRP GLY ASN PRO LEU PRO GLU LEU LYS CYS LEU LYS ASP GLY THR PHE PRO LEU PRO

FIG. 1B

ATC GGG GAA TCA GTG ACT GTC ACT CGA GAT CTT GAG GGC ACC TAC CTC TGT CGG GCC AGG AGC ACT
 ILE GLY GLU SER VAL THR VAL THR ARG ASP LEU GLU GLY THR TYR LEU CYS ARG ALA ARG SER THR

 CAA GGG GAG GTC ACC CGC GAG GTG ACC GTG AAT GTG CTC TCC CCC CGG TAT GAG ATT GTC ATC ATC
 GLN GLY GLU VAL THR ARG GLU VAL THR VAL ASN VAL LEU SER PRO ARG TYR GLU ILE VAL ILE ILE

 ACT GTG GTA GCA GCC GCA GTC ATA ATG GGC ACT GCA GGC CTC AGC ACC TAC CTC TAT AAC CGC CAG
 THR VAL VAL ALA ALA VAL ILE MET GLY THR ALA GLY LEU SER THR TYR LEU TYR ASN ARG GLN

 CGG AAG ATC AAG AAA TAC AGA CTA CAA CAG GCC CAA AAA GGG ACC CCC ATG AAA CCG AAC ACA CAA
 ARG LYS ILE LYS LYS TYR ARG LEU GLN GLN ALA GLN LYS GLY THR PRO MET LYS PRO ASN THR GLN

 GCC ACG CCT CCC TGA ACCTATCCCG GGACAGGGCC TCTTCTCGG CCTTCCCATATA TTGGTGGCAG TGGTGCCACA
 ALA THR PRO PRO ***

 CTGAACAGAG TGAAGACAT ATGCCATGCA GCTACACCTA CCGGCCCTGG GACGCCGGAG GACAGGGCAT TGTCTCAGT
 CAGATACAAC AGCATTGCGG GCCATGGTAC CTGCACACCT AAAACACTAG GCCACGCATC TGATCTGTAG TCACATGACT
 AAGCCAAGAG GAAGGAGCAA GACTCAAGAC ATGATTGATG GATGTTAAAG TCTAGCCTGA TGAGAGGGGA AGTGGTGGGG
 GAGACATAGC CCCACCATGA GGACATACAA CTGGGAATA CTGAAACTTG CTGCCTATTG GGTATGCTGA GGCCACAGA
 CTTACAGAAG AAGTGCCCT CCATAGACAT GTGTAGCATC AAAACACAAA GGCCACACT TCCTGACGGA TGCCAGCTTG
 GGCACTGCTG TCTACTGACC CCAACCCCTTG ATGATATGTA TTTATTTCATT TGTATTTTTA CCAGCTATTT ATTGAGTGTC
 TTTTATGTAG GCTAAATGAA CATAGGTCTC TGGCCTCAGG GAGCTCCCAG TCCATGTCAC ATTCAAGGTC ACCAGGTACA
 GTTGACAGG TTGTACACTG CAGGAGAGTG CCTGGCAAAA AGATCAAAATG GGGCTGGGAC TTCTCATTTG CCAACCTGCC
 TTTCCCCAGA AGGAGTGATT TTTCTATCGG CACAAAAGCA CTATATGGAC TGGTAATGGT TCACAGGTTT AGAGATTACC

FIG. 1C

CAGTGAGGCC TTATTCCCTCC CTTCCCCCCA AACTGACAC CTTTGTTAGC CACCTCCCCA CCCACATACA TTTCTGCCAG
 TGTTACAATG ACACTCAGCG GTCATGTCTG GACATGAGTG CCCAGGGAAT ATGCCCAAGC TATGCCCTTGT CCTCTTGTCC
 TGTTTGCATT TCACTGGGAG CTTGCACTAT TGCAGCTCCA GTTTCCTGCA GTGATCAGGG TCCTGCAAGC AGTGGGGAAG
 GGGGCCAAGG TATTGGAGGA CTCCCTCCCA GCTTTGGAAG GGTCAATCCG GTGTGTGTGT GTGTGTATGT GTAGACAAGC
 TCTCGCTCTG TCACCCAGGC TGGAGTGCAG TGGTGCAATC ATGGTTCACT GCAGTCTTGA CCTTTTGGGC TCAAGTGATC
 CTCCCACCTC AGCCTCCTGA GTAGCTGGA CCATAGGCTC ACAACACCAC ACCTGGCAAA TTTGATTTT TTTTTTTTT
 TCAGAGACGG GGTCTCGCAA CATTGCCCAG ACTTCCTTG TGTAGTTAA TAAAGCTTTC TCAACTGCCA AAAAAAAAAA
 AAAAAA

FIG. 1D

FIG. 2A

TTCACATCAA AACTCCTATA CTGACCTGAG ACAGAGGCAG CAGTGATACC CACCTGAGAG ATCCTGTGTT TGA
 ACAACTG CTTCCCAAAA CGGAAAGTAT TTCAAGCCTA AACCTTTGGG TGAAGAAGAC TCTTGAAGTC ATG ATT
 met ile
 GCT TCA CAG TTT CTC TCA GCT CTC ACT TTG GTG CTT CTC ATT AAA GAG AGT GGA GCC TGG
 ala ser gln phe leu ser ala leu thr leu val leu leu ile lys glu ser gly ala trp
 TCT TAC AAC ACC TCC ACG GAA GCT ATG ACT TAT GAT GAG GCC AGT GCT TAT TGT CAG CAA
 ser tyr asn thr ser thr glu ala met thr tyr asp glu ala ser ala tyr cys gln gln
 AGG TAC ACA CAC CTG GTT GCA ATT CAA AAC AAA GAA GAG ATT GAG TAC CTA AAC TCC ATA
 arg tyr thr his leu val ala ile gln asn lys glu glu ile glu tyr leu asn ser ile
 TTG AGC TAT TCA CCA AGT TAT TAC TGG ATT GGA ATC AGA AAA GTC AAC AAT GTG TGG GTC
 leu ser tyr ser pro ser tyr tyr trp ile gly ile arg lys val asn asn val trp val
 TGG GTA GGA ACC CAG AAA CCT CTG ACA GAA GAA GCC AAG AAC TGG GCT CCA GGT GAA CCC
 trp val gly thr gln lys pro leu thr glu glu ala lys asn trp ala pro gly glu pro
 AAC AAT AGG CAA AAA GAT GAG GAC TGC GTG GAG ATC TAC ATC AAG AGA GAA AAA GAT GTG
 asn asn arg gln lys asp glu asp cys val glu ile tyr ile lys arg glu lys asp val
 GGC ATG TGG AAT GAT GAG AGG TGC AGC AAG AAG AAG CTT GCC CTA TGC TAC ACA GCT GCC
 gly met trp asp glu arg cys ser lys lys leu ala leu cys tyr thr ala ala
 TGT ACC AAT ACA TCC TGC AGT GGC CAC GGT GAA TGT GTA GAG ACC ATC AAT AAT TAC ACT
 cys thr asn thr ser cys ser gly his gly glu cys val glu thr ile asn asn tyr thr
 TGC AAG TGT GAC CCT GGC TTC AGT GGA CTC AAG TGT GAG CAA ATT GTG AAC TGT ACA GCC
 cys lys cys asp pro gly phe ser gly leu lys cys glu gln ile val asn cys thr ala

CTG GAA TCC CCT GAG CAT GGA AGC CTG GTT TGC AGT CAC CCA CTG GGA AAC TTC AGC TAC
 leu glu ser pro glu his gly ser leu val cys ser his pro leu gly asn phe ser tyr

 AAT TCT TCC TGC TCT ATC AGC TGT GAT AGG GGT TAC CTG CCA AGC ATG GAG ACC ATG
 asn ser ser cys ser ile ser cys asp arg gly tyr leu pro ser ser met glu thr met

 CAG TGT ATG TCC TCT GGA GAA TGG AGT GCT CCT ATT CCA GCC TGC AAT GTG GTT GAG TGT
 gln cys met ser ser gly glu trp ser ala pro ile pro ala cys asn val val glu cys

 GAT GCT GTG ACA AAT CCA GCC AAT GGG TTC GTG GAA TGT TTC CAA AAC CCT GGA AGC TTC
 asp ala val thr asn pro ala asn gly phe val glu cys phe gln asn pro gly ser phe

 CCA TGG AAC ACA ACC TGT ACA TTT GAC TGT GAA GAA GGA TTT GAA CTA ATG GGA GCC CAG
 pro trp asn thr thr cys thr phe asp cys glu glu gly phe glu leu met gly ala gln

 AGC CTT CAG TGT ACC TCA TCT GGG AAT TGG GAC AAC GAG AAG CCA ACG TGT AAA GCT GTG
 ser leu gln cys thr ser ser gly asp asn trp asp asn glu lys pro thr cys lys ala val

 ACA TGC AGG GCC GTC CGC CAG CCT CAG AAT GGC TCT GTG AGG TGC AGC CAT TCC CCT GCT
 thr cys arg ala val arg gln pro gln asn gly ser val arg cys ser his ser pro ala

 GGA GAG TTC ACC TTC AAA TCA TCC TGC AAC TTC ACC TGT GAG GAA GGC TTC ATG TTG CAG
 gly glu phe thr phe lys ser ser cys asn phe thr cys glu glu gly phe met leu gln

 GGA CCA GCC CAG GTT GAA TGC ACC ACT CAA GGG CAG TGG ACA CAG CAA ATC CCA GTT TGT
 gly pro ala gln val glu cys thr thr gln gly gln trp thr gln gln ile pro val cys

 GAA GCT TTC CAG TGC ACA GCC TTG TCC AAC CCC GAG CGA GGC TAC ATG AAT TGT CTT CCT
 glu ala phe gln cys thr ala leu ser asn pro glu arg gly tyr met asn cys leu pro

FIG. 2B

AGT GCT TCT GGC AGT TTC CGT TAT GGG TCC AGC TGT GAG TTC TCC TGT GAG CAG GGT TTT
 ser ala ser gly ser phe arg tyr gly ser ser ser cys glu phe ser cys glu gln gly phe

 GTG TTG AAG GGA TCC AAA AGG CTC CAA TGT GGC CCC ACA GGG GAG TGG GAC AAC GAG AAG
 val leu lys gly ser lys arg leu gln cys gly pro thr thr gly glu trp asp asn glu lys

 CCC ACA TGT GAA GCT GTG AGA TGC GAT GCT GTC CAC CAG CCC CCG AAG GGT TTG GTG AGG
 pro thr cys glu ala val arg cys asp ala val his gln pro pro lys gly leu val arg

 TGT GCT CAT TCC CCT ATT GGA GAA TTC ACC TAC AAG TCC TCT TGT GCC TTC AGC TGT GAG
 cys ala his ser pro ile gly glu phe thr tyr lys ser ser cys ala phe ser cys glu

 GAG GGA TTT GAA TTA TAT GGA TCA ACT CAA CTT GAG TGC TCC ACA TCT CAG GGA CAA TGG ACA
 glu gly phe glu leu leu tyr gly ser thr thr gln leu glu cys thr ser gln gly gln trp thr

 GAA GAG GTT CCT TCC TGC CAA GTG GTA AAA TGT TCA AGC CTG GCA GTT CCG GGA AAG ATC
 glu glu val pro ser cys gln val val lys cys ser ser leu ala val pro gly lys ile

 AAC ATG AGC TGC AGT GGG GAG CCC GTG TTT GGC ACT GTG TGC TGC AAG TTC GCC TGT CCT GAA
 asn met ser cys ser gly glu pro val phe gly thr thr val cys lys phe ala cys pro glu

 GGA TGG ACG CTC AAT GGC TCT GCA GCT CGG ACA TGT GGA GCC ACA GGA CAC TGG TCT GGC
 gly trp thr leu asn gly ser ala ala arg thr cys gly ala thr gly his trp ser gly

 CTG CTA CCT ACC TGT GAA GCT CCC ACT GAG TCC AAC ATT CCC TTG GTA GCT GGA CTT TCT
 leu leu pro thr cys glu ala pro thr glu ser asn ile pro leu val ala gly leu ser

 GCT GCT GGA CTC TCC CTC CTG ACA TTA GCA CCA TTT CTC CTC TGG CTT CGG AAA TGC TTA
 ala ala gly leu ser leu leu thr leu ala pro phe leu leu trp leu arg lys cys leu

 CGG AAA GCA AAG AAA TTT GTT CCT GCC AGC AGC TGC CAA AGC CTT GAA TCA GAC GGA AGC
 arg lys ala lys lys phe val pro ala ser ser cys gln ser leu glu ser asp gly ser

FIG. 2C

TAC CAA AAG CCT TCT TAC ATC CTT TAA GTTCAAA AGAATCAGAA ACAGGTGCAT CTGGGGAACT A
 tyr gln lys pro ser tyr ile leu ***
 GAGGGATAC ACTGAAGTTA ACAGAGACAG ATAACTCTCC TCGGGTCTCT GGCCTTCTT GCCTACTATG CCAG
 ATGCCCT TTATGGCTGA AACCGCAACA CCCATCACCA CTTCAATAGA TCAAAGTCCA GCAGGCAAGG ACGGCCCT
 TCA ACTGAAAAGA CTCAGTGTTT CCTTTCCTAC TCTCAGGATC AAGAAAGTGT TGGCTAATGA AGGGAAGGA
 TATTTTCTTC CAAGCAAGG TGAAGAGACC AAGACTCTGA AATCTCAGAA TTCTTTTCT AACTCTCCCT TG
 CTCGCTGT AAAATCTTGG CACAGAAACA CAATATTTTG TGGCTTCTT TCTTTTGCCC TTCACAGTGT TTCGA
 CAGCT GATTACACAG TTGCTGTCAT AAGAATGAAT AATAATTATC CAGAGTTAG AGGAAAAAAA TGAATAAA
 AA TATTATAACT TAAAAAATG ACAGATGTTG AATGCCCCACA GGCAATGCA TGGAGGGGTG TTAATGGTGC
 AAATCCTACT GAATGCTCTG TCGGAGGGTT ACTATGCACA ATTTAATCAC TTTTCATCCCT ATGGGATTCA GTG
 CTCTTA AAGAGTTCTT AAGGATTGTG ATATTTTAC TTGCATTGAA TATATTATAA TCTTCCATAC TTCTTC
 ATTC AATACAAGTG TGGTAGGAC TAAAAAACT TGTAATGCT GTCAACTATG ATATGGTAA AGTTACTTA
 T TCTAGATTAC CCCCTCATTG TTTATTACA AATTATGTTA CATCTGTTT AAATTATT CAAAAAGGA A
 ACTATTGTC CCCTAGCAAG GCATGATGTT AACCAGAATA AAGTTCTGAG TGTTTTACT ACAGTTGTTT TTG
 AAAACA TGGTAGAATT GGAGAGTAAA AACTGAATGG AAGTTTGA TATTGTCAGA TATTTTTTCA GAAATAT
 GTG GTTCCACGA TGAAAAACTT CCATGAGGCC AAACGTTTG AACTAATAA AGCATAAATG CAAACACACA
 AAGGTATAAT TTTATGAATG TCTTTGTTGG AAAAGAATAC AGAAAGATGG ATGTGCTTG CATTCCTACA AA
 GATGTTG TCAGATGTGA TATGTAAACA TAACTCTTGT ATATTATGGA AGATTTTAA TTCACAATAG AAAC

FIG. 2D

CACCA TGTAAAAGAG TCATCTGGTA GATTTTAAAC GAATGAAGAT GTCTAATAGT TATTCCTAT TTGTTTTTC
TT CTGTATGTTA GGGTGCTCTG GAAGAGAGGA ATGCCTGTGT GAGCAAGCAT TTATGTTTAT TTATAAGCAG
ATTAAACAAT TCCAAAGGAA TCTCCAGTTT TCAGTTGATC ACTGGCAATG AAAAATTCTC AGTCAGTAAT TGC
CAAAGCT GCTCTAGCCT TGAGGAGTGT GAGAAATCAAA ACTCTCCTAC ACTTCCATTA ACTTAGCATG TGTGTA
AAAA AAAAGTTTCA GAGAAGTTCT GGCTGAACAC TGGCAACGAC AAAGCCCAACA GTCAAAAACAG AGATGTGAT
A AGGATCAGAA CAGCAGAGGT TCTTTTAAAG GGCAGAAAA ACTCTGGGAA ATAAGAGAGA ACAACTACTG T
GATCAGGCT ATGTATGGAA TACAGTGTTA TTTTCTTTGA AATTGTTTAA GGTGTGTAAT TATTTATGTA AACT
GCATTA GAAATTAGCT GTGTGAAATA CCAGTGTGGT TTGTGTTTGA GTTTTATGTA GAAATTTTAA TTATAAC
TTA AAATATTTTA TAATTTTTAA AGTATATATT TATTTAAGCT TATGTCAGAC CTATTTTGACA TAACACTATA
AAGTTTGACA ATAAATGTGC TTATGTTT

FIG. 2E

FIG. 3A

CGGGCCTCAC TGGCTTCAGG AGCTGAATAC CCTCCAGGC ACACACAGGT GGGACACAAA TAAGGGTTTT GGA

ACCACTA TTTTCTCATC ACGACAGCAA CTTAAA ATG CCT GGG AAG ATG GTC GTG ATC CTT GGA GCC
 met pro gly lys met val val ile leu gly ala

TCA AAT ATA CTT TGG ATA ATG TTT GCA GCT TCT CAA GCT TTT AAA ATC GAG ACC ACC CCA
 ser asn ile leu trp ile met phe ala ala ser gln ala phe lys ile glu thr thr pro

GAA TCT AGA TAT CTT GCT CAG ATT GGT GAC TCC GTC TCA TTG ACT TGC AGC ACC ACA GGC
 glu ser arg tyr leu ala gln ile gly asp ser val ser leu thr cys ser thr thr gly

TGT GAG TCC CCA TTT TTC TCT TGG AGA ACC CAG ATA GAT AGT CCA CTG AAT GGG AAG GTG
 cys glu ser pro phe phe ser trp arg thr gln ile asp ser pro leu asn gly lys val

ACG AAT GAG GGG ACC ACA TCT ACG CTG ACA ATG AAT CCT GTT AGT TTT GGG AAC GAA CAC
 thr asn glu gly thr thr ser thr leu thr met asn pro val ser phe gly asn glu his

TCT TAC CTG TGC ACA GCA ACT TGT GAA TCT AGG AAA TTG GAA AAA GGA ATC CAG GTG GAG
 ser tyr leu cys thr ala thr cys glu ser arg lys leu glu lys gly ile gln val glu

ATC TAC TCT TTT CCT AAG GAT CCA GAG ATT CAT TTG AGT GGC CCT CTG GAG GCT GGG AAG
 ile tyr ser phe pro lys asp pro glu ile his leu ser gly pro leu glu ala gly lys

CCG ATC ACA GTC AAG TGT TCA GTT GCT GAT GTA TAC CCA TTT GAC AGG CTG GAG ATA GAC
 pro ile thr val lys cys ser val ala asp val tyr pro phe asp arg leu glu ile asp

TTA CTG AAA GGA GAT CAT CTC ATG AAG AGT CAG GAA TTT CTG GAG GAT GCA GAC AGG AAG
 leu leu lys gly asp his leu met lys ser gln glu phe leu glu asp ala asp arg lys

TCC CTG GAA ACC AAG AGT TTG GAA GTA ACC TTT ACT CCT GTC ATT GAG GAT ATT GGA AAA
 ser leu glu thr lys ser leu glu val thr phe thr pro val ile glu asp ile gly lys

GTT CTT GTT TGC CGA GCT AAA TTA CAC ATT GAT GAA ATG GAT TCT GTG CCC ACA GTA AGG
 val leu val cys arg ala lys leu his ile asp glu met asp ser val pro thr val arg

CAA GCT GTA AAA GAA TTG CAA GTC TAC ATA TCA CCC AAG AAT ACA GTT ATT TCT GTG AAT
 gln ala val lys glu leu gln val tyr ile ser pro lys asn thr val ile ser val asn
 CCA TCC ACA AAG CTG CAA GAA GGT GGC TCT GTG ACC ATG ACC TGT TCC AGC GAG GGT CTA
 pro ser thr lys leu gln glu gly ser val thr met thr cys ser ser glu gly leu
 CCA GCT CCA GAG ATT TTC TGG AGT AAG AAA TTA GAT AAT GGG AAT CTA CAG CAC CTT TCT
 pro ala pro glu ile phe trp ser lys lys leu asp asn gly asn leu gln his leu ser
 GGA AAT GCA ACT CTC ACC TTA ATT GCT ATG AGG ATG GAA GAT TCT TCT GGA ATT TAT GTG TGT
 gly asn ala thr leu thr leu ile ala met arg met glu asp ser gly ile tyr val cys
 GAA GGA GTT AAT TTG ATT GGG AAA AAC AGA AAA GAG GTG GAA TTA ATT GTT CAA GCA TTC
 glu gly val asn leu ile gly lys asn arg lys glu val glu leu ile val gln ala phe
 CCT AGA GAT CCA GAA ATC GAG ATG AGT GGT GGC CTC GTG AAT GGG AGC TCT GTC ACT GTA
 pro arg asp pro glu ile glu met ser gly gly leu val asn gly ser ser val thr val
 AGC TGC AAG GTT CCT AGC GTG TAC CCC CTT GAC CGG CTG GAG ATT GAA TTA CTT AAG GGG
 ser cys lys val pro ser val tyr pro leu asp arg leu glu ile glu leu leu lys gly
 GAG ACT ATT CTG GAG AAT ATA GAG TTT TTG GAG GAT ACC GAT ATG AAA TCT CTA GAG AAC
 glu thr ile leu glu asn ile glu phe leu glu asp thr asp met lys ser leu glu asn
 AAA AGT TTG GAA ATG ACC TTC ATC CCT ACC ATT GAA GAT ACT GGA AAA GCT CTT GTT TGT
 lys ser leu glu met thr phe ile pro thr ile glu asp thr gly lys ala leu val cys
 CAG GCT AAG TTA CAT ATT GAT GAC ATG GAA TTC GAA CCC AAA CAA AGG CAG AGT ACG CAA
 gln ala lys leu his ile asp asp met glu phe glu pro lys gln arg gln ser thr gln
 ACA CTT TAT GTC AAT GTT GCC CCC AGA GAT ACA ACC GTC TTG GTC AGC CCT TCC TCC ATC
 thr leu tyr val asn val ala pro arg asp thr thr val leu val ser pro ser ser ile
 CTG GAG GAA GGC AGT TCT GTG AAT ATG ACA TGC TTG AGC CAG GGC TTT CCT GCT CCG AAA
 leu glu glu gly ser ser val asn met thr cys leu ser gln gly phe pro ala pro lys

FIG. 3B

ATC CTG TGG AGC AGG CAG CTC CCT AAC GGG GAG CTA CAG CCT CTT TCT GAG AAT GCA ACT
 ile leu trp ser arg gln leu pro asn gly glu leu gln pro leu ser glu asn ala thr
 CTC ACC TTA ATT TCT ACA AAA ATG GAA GAT TCT GGG GTT TAT TTA TGT GAA GGA ATT AAC
 leu thr leu ile ser thr lys met glu asp ser gly val tyr leu cys glu gly ile asn
 CAG GCT GGA AGA AGC AGA AAG GAA GTG GAA TTA ATT ATC CAA GTT ACT CCA AAA GAC ATA
 gln ala gly arg ser arg lys glu val glu leu ile ile gln val thr pro lys asp ile
 AAA CTT ACA GCT TTT CCT TCT GAG AGT GTC AAA GAA GGA GAC ACT GTC ATC ATC TCT TGT
 lys leu thr ala phe pro ser glu ser val lys glu gly asp thr val ile ile ser cys
 ACA TGT GGA AAT GTT CCA GAA ACA TGG ATA ATC CTG AAG AAA AAA GCG GAG ACA GGA GAC
 thr cys gly asn val pro glu thr trp ile ile leu lys lys ala glu thr gly asp
 ACA GTA CTA AAA TCT ATA GAT GGC GCC TAT ACC ATC CGA AAG GCC CAG TTG AAG GAT GCG
 thr val leu lys ser ile asp gly ala tyr thr ile arg lys ala gln leu lys asp ala
 GGA GTA TAT GAA TGT GAA TCT AAA AAC AAA GTT GGC TCA CAA TTA AGA AGT TTA ACA CTT
 gly val tyr glu cys glu ser lys asn lys val gly ser gln leu arg ser leu thr leu
 GAT GTT CAA GGA AGA GAA AAC AAC AAA GAC TAT TTT TCT CCT GAG CTT CTC GTG CTC TAT
 asp val gln gly arg glu asn asn lys asp tyr phe ser pro glu leu val leu tyr
 TTT GCA TCC TCC TTA ATA ATA CCT GCC ATT GGA ATG ATA ATT TAC TTT GCA AGA AAA GCC
 phe ala ser ser leu ile ile pro ala ile gly met ile ile tyr phe ala arg lys ala
 AAC ATG AAG GGG TCA TAT AGT CTT GTA GAA GCA CAG AAA TCA AAA GTG TAG CTAATGCTTG
 asn met lys gly ser tyr ser leu val glu ala gln lys ser lys val ***
 ATATGTTCAA CTGGAGACAC TATTTATCTG TGCAATCCT TGATACTGCT CATCATTCCT TGAGAAAAAC AAT
 GAGCTGA GAGGCAGACT TCCCTGAATG TATTGAACTT GGAAGAAAT GCCCATCTAT GTCCCTTGCT GTGAGC
 AGA AGTCAAAGTA AAACCTTGCTG CCTGAAGAAC AGTAACTGCC ATCAAGATGA GAGAACTGGA GGAGTTCCT
 T GATCTGTATA TACAAATAACA TAAATTTGTAC ATATGTAAAA TAAATTTATG CCATAGCAAG ATTGCTTAAAA

FIG. 3C

TAGCAACAC TCTATATTTA GATTGTTAA ATAACTAGTG TTGCTTGGAC TATTATAATT TAATGCATGT TAGG
AAAATT TCACATTTAAT ATTTGCTGAC AGCTGACCCT TGTCATCTTT CTTCATTTTT ATTCCCTTTC ACAAAAT
TTT ATTCCCTATAT AGTTTATTGA CAATAATTTC AGGTTTGTGA AAGATGCCCG GTTTTATATT TTTATAGACA
AATAATAAGC AAAGGGAGCA CTGGGTTGAC TTTCAGGTAC TAAATACCCT AACCTATGGT ATAATGGTTG AC
TGGGTTTC TCTGTATAGT ACTGGCATGG TACGGAGATG TTTCACGAAG TTTGTTTCATC AGACTCCTGT GCAAC
TTTCC CAATGTGGCC TAAAAATGCA ACTTCTTTTT ATTTCTTTTT GTAAATGTTT AGGTTTTTTT GTATAGTA
AA GTGATAATTT CTGGAATTAA AAA

FIG. 3D

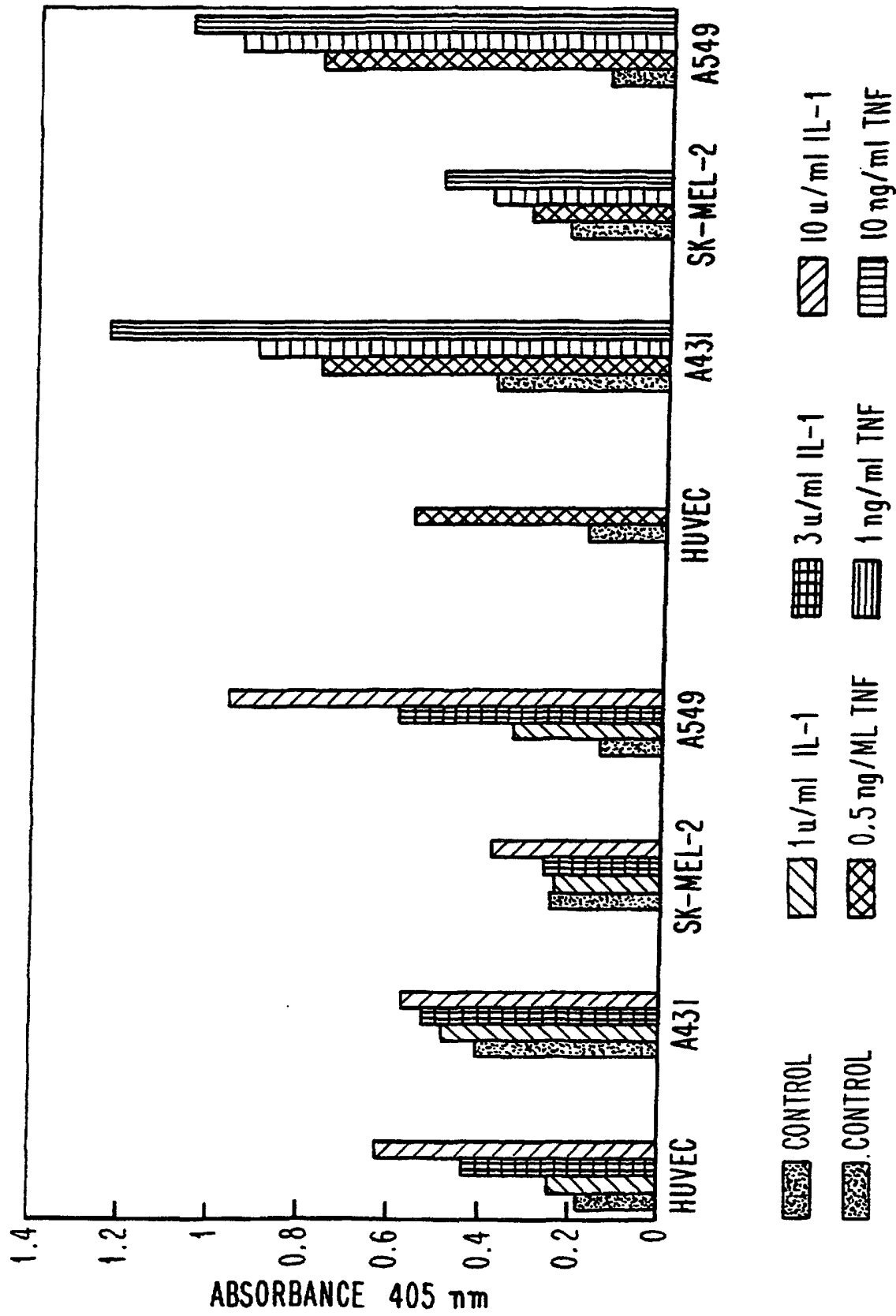


FIG. 4

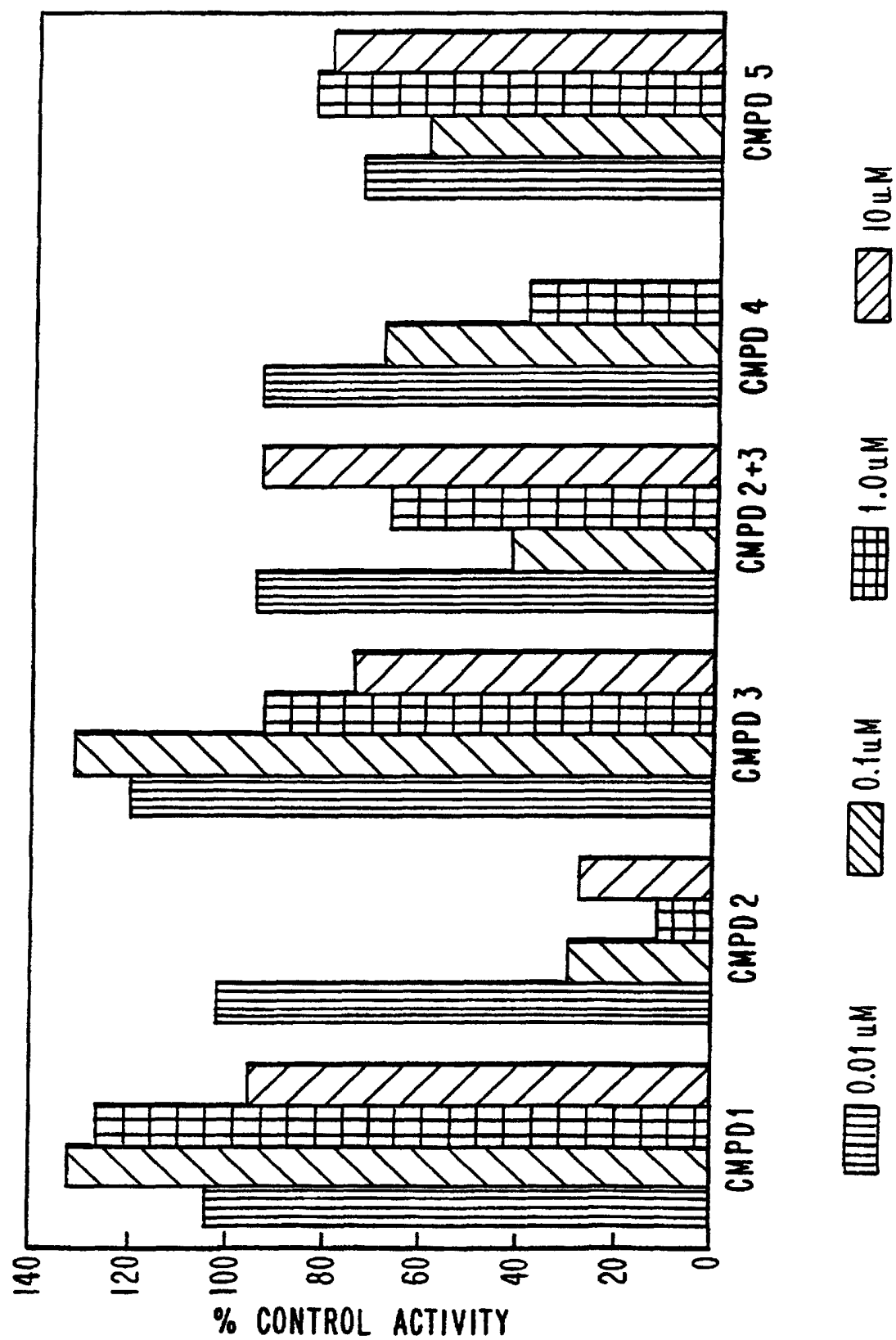
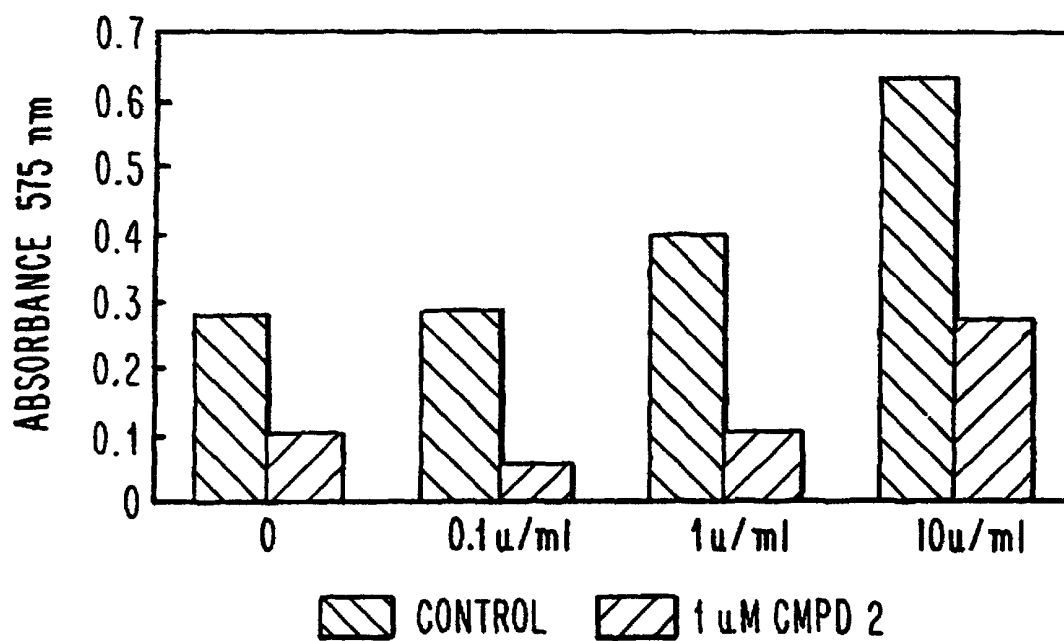
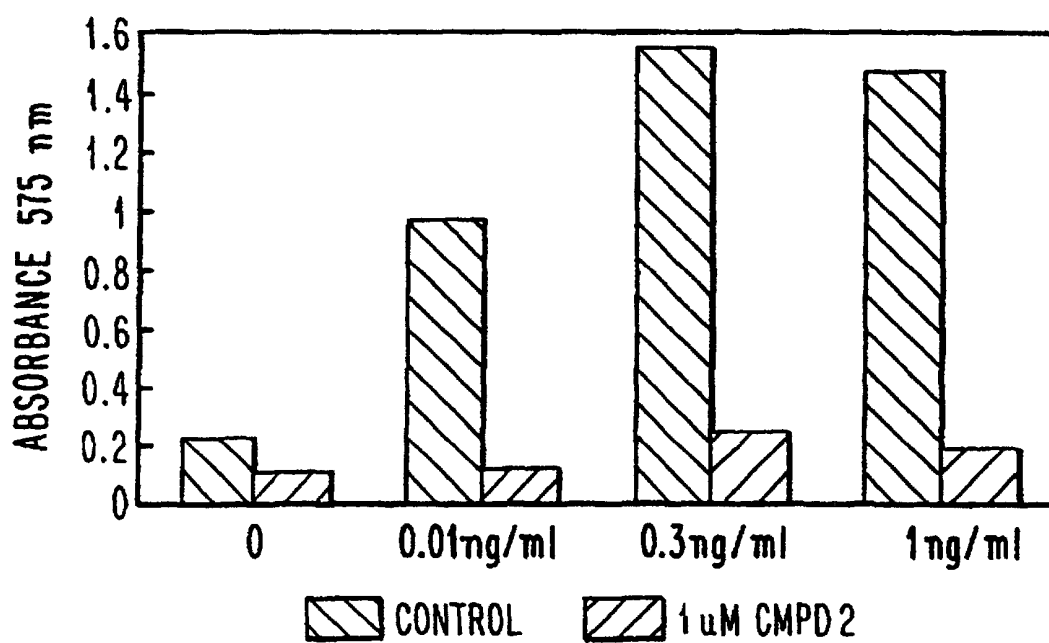


FIG. 5

**FIG. 6A****FIG. 6B**

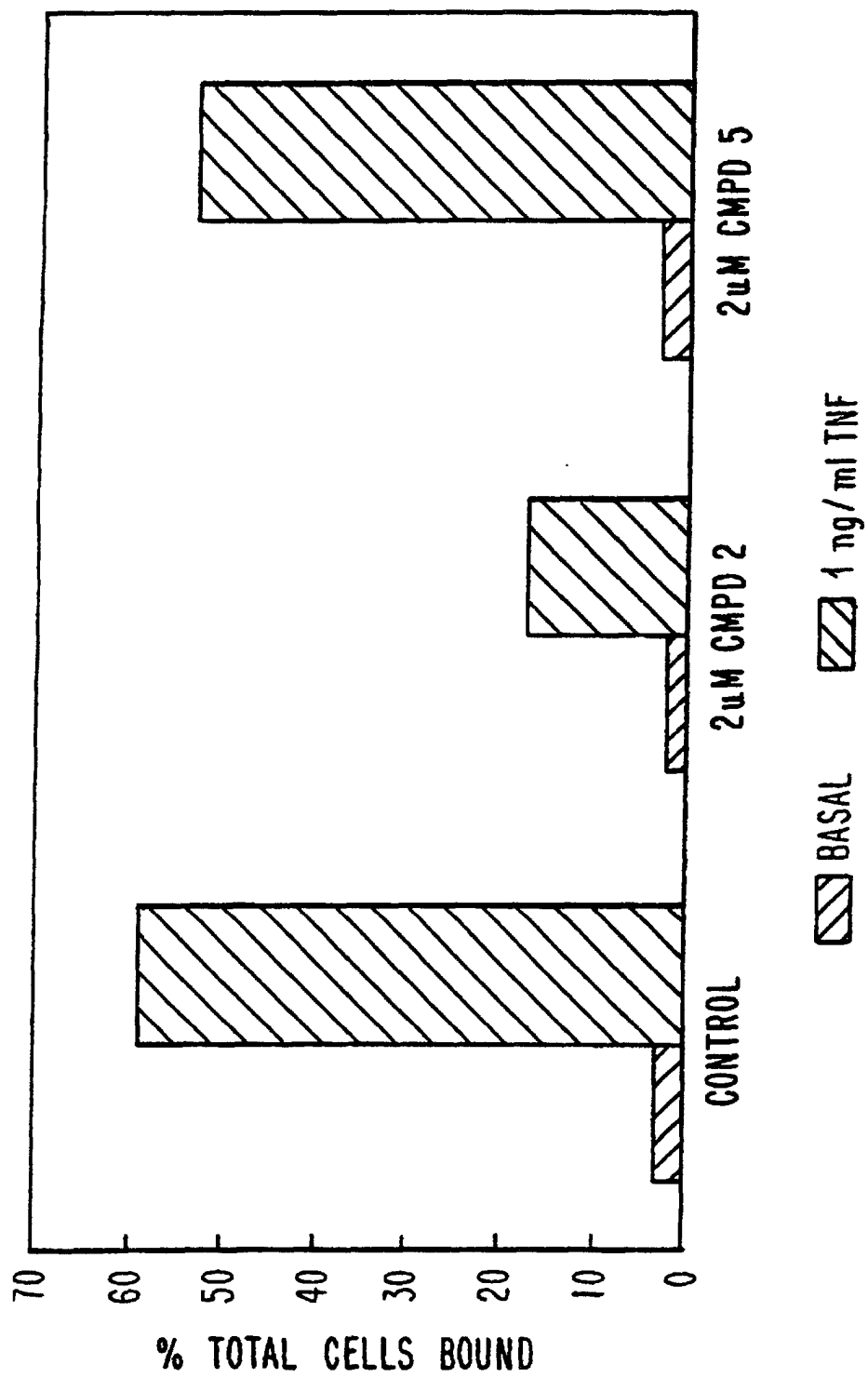
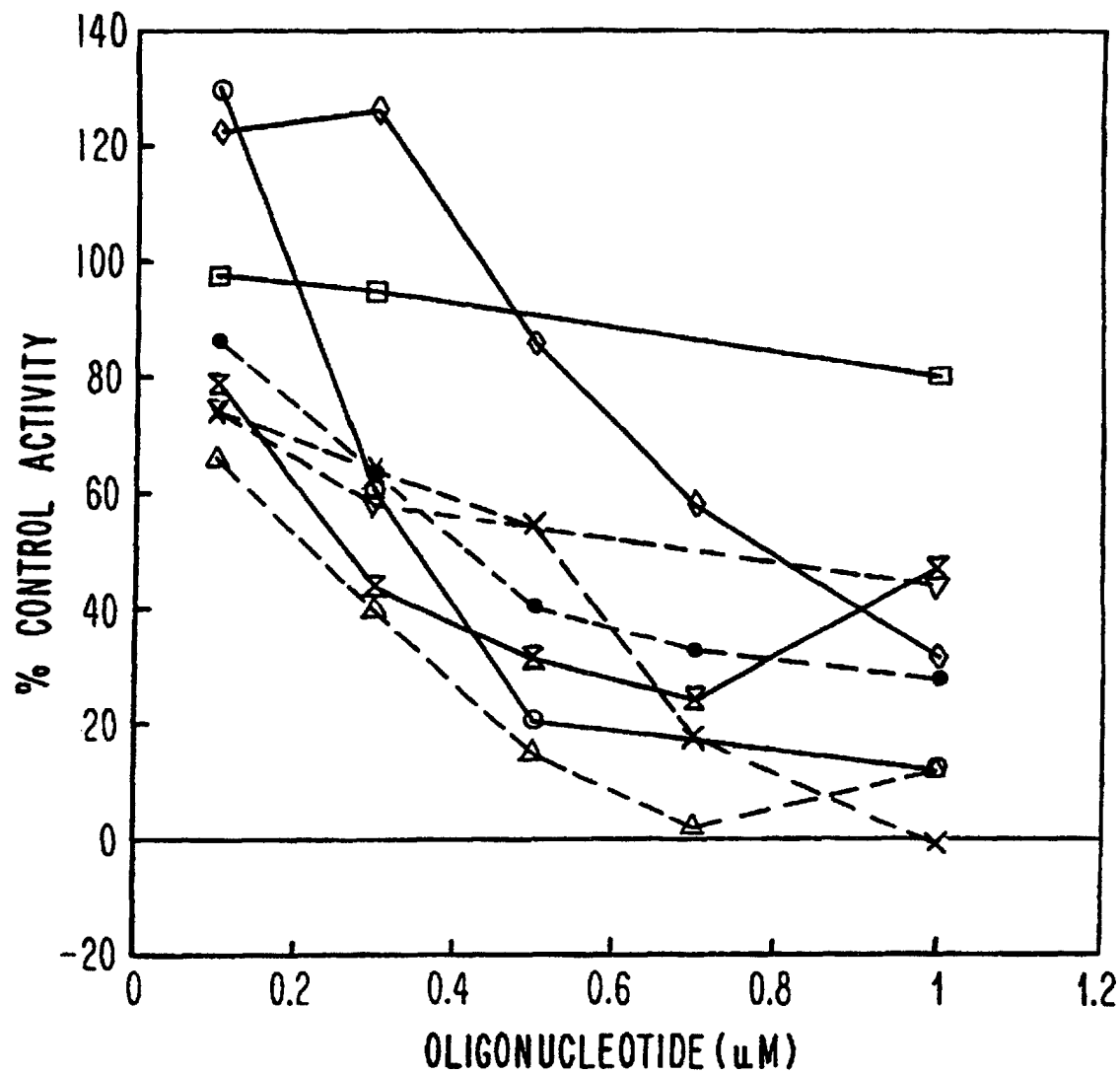


FIG. 7



● 1570 ○ 3067 ▽ 1931 □ 1932
× 1939 ◇ 2307 △ 2302 ⊗ 1938

FIG. 8

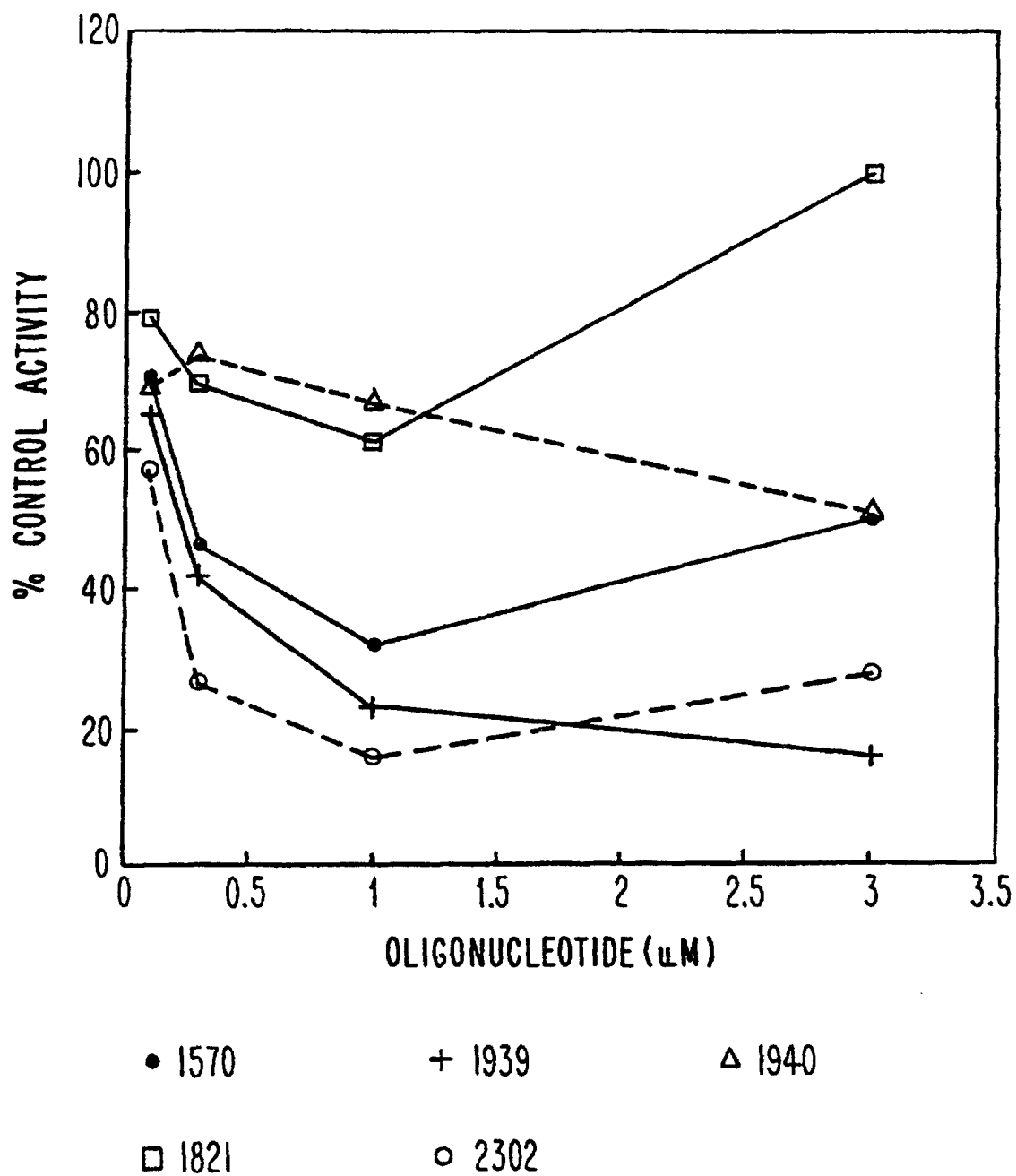
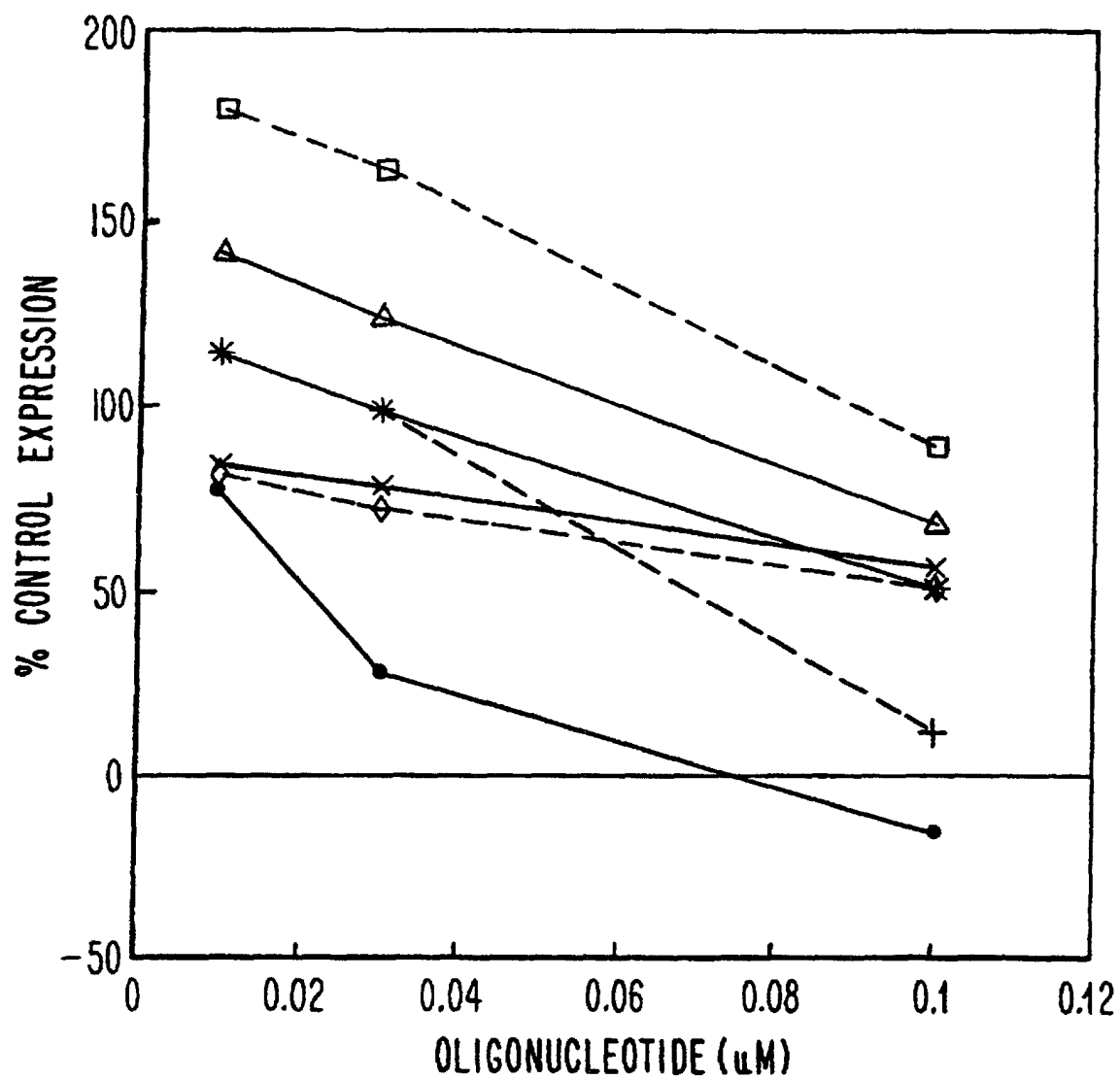


FIG. 9



• 2679 + 2674 * 2673 □ 2687
× 2686 ◇ 2683 △ 1571 (ICAM-1)

FIG. 12

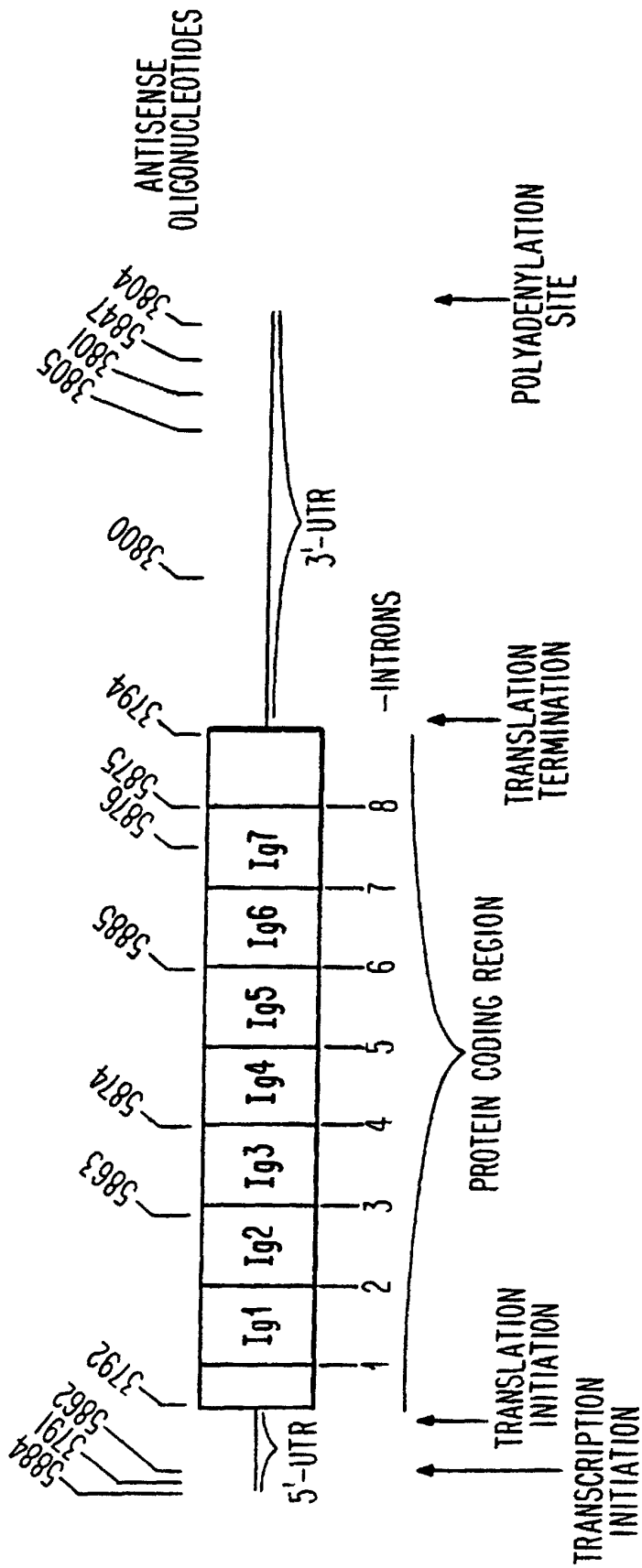


FIG. 14

(Keine weitere
Abbildung)